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DIURNAL ACTIVITY RHYTHMS IN FRESH-WATER FISHES

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INTRODUCTION

Rhythmic phenomena involving the orderly recurrence of events are characteristic of inanimate nature. Many of the activities of plants and animals are also marked by physiological rhythms. Their tempo may be extremely rapid as in volleys of nerve impulses passing along a nerve fiber, the heart-beat, or ciliary activity. In such cases the rhythm seems to be determined by a discharge-recovery mechanism associated with the physico-chemical nature of the process. Other activity rhythms have a longer cycle, sometimes of days or even months duration. The physiological rhythm may coincide in time with a rhythmic phenomenon in the physical environment in such a way as to leave little doubt that there is a relationship between the two. Among the commonest of these are activities of plants and animals correlated with the 24-hour cycle and known as diurnal rhythms.

The diurnal-nocturnal fluctuation in light intensity and temperature would be expected to affect certain physiological processes directly and others indirectly. But in some cases when these factors are held constant the physiological rhythm persists over long periods of time. These are then referred to as "innate" rhythms. However, little is known as to whether such phenomena are acquired or racial characters. It is not our intention here to review the literature on diurnal rhythms. The reader is referred to a recent review of the subject by Welsh (1938).

General activity, the sum total of the gross body movements of an animal, is a rough measure of the metabolic rate and can in turn be measured over longer or shorter time intervals

by the use of appropriate apparatus. Szymanski, a pioneer in this field, (1914, 1919) has studied activity in many species of animals by the use of ingenious devices which he designates "actographs." Under conditions as nearly normal as the experimental method would allow he has shown that the activity rhythms of different organisms tend to fall into two general classes. The first class includes those forms which in a 24-hour cycle show a single sustained period of activity followed by one of absolute or relative rest. Such a cycle he designates as "monophasic." In a second type more than one period of activity alternate with a corresponding number of rest periods in a 24-hour cycle. From a consideration of the data Szymanski concludes that the monophasic organisms have their behavior pattern largely influenced by visual stimuli, while in "polyphasic" forms vision plays a role secondary to gustatory, olfactory, or other stimuli.

The most complete study of nocturnal-diurnal rhythm which has come to our attention is that of Johnson (1926) on the forest deer-mouse. By prolonged observations, using a quantitative recording device, he has demonstrated an innate rhythm in this animal with a period of increased activity at night. This was shown to persist even in total darkness. Other experiments have demonstrated the persistence over considerable periods of time, even under constant light and temperature, of activity rhythms of the monophasic type in various species of animals. The data in this field indicate that there is present a rather deeply established 24-hour rhythm in certain animals, but that this may sometimes be altered by external stimuli. This alteration does not, of course, answer the question as to whether the rhythm is an acquired or an inherited one.

We shall here report a series of preliminary experiments dealing with total activity over periods of from one to several days duration in ten species of fresh-water fish. In all 32 specimens were used and quantitative records totaling 267 days and 8 hours were secured.

APPARATUS AND METHODS

Some years ago in the course of studies on the lateral line nerve of the goldfish in the laboratory of animal behavior at the Ohio State University it became apparent that a method of securing quantitative data on total activity would be of

advantage. The apparatus shown in Figure 1 and described under the name of "ichthyometer" (Spencer, 1929) was designed to meet this need. It consists of an extremely light lever, with an adjustable counter-weight on the short recording arm. To the end of the long arm a thread is attached which runs through a rigid screw-eye, fixed about half an inch above the water at one end of the experimental tank. This thread is attached to the dorsum of the fish near the tail by a loop of thread or light aluminum wire. The counter-weight is so adjusted that the short arm is slightly heavier than the long arm, but a pull of approximately one gram will move the lever

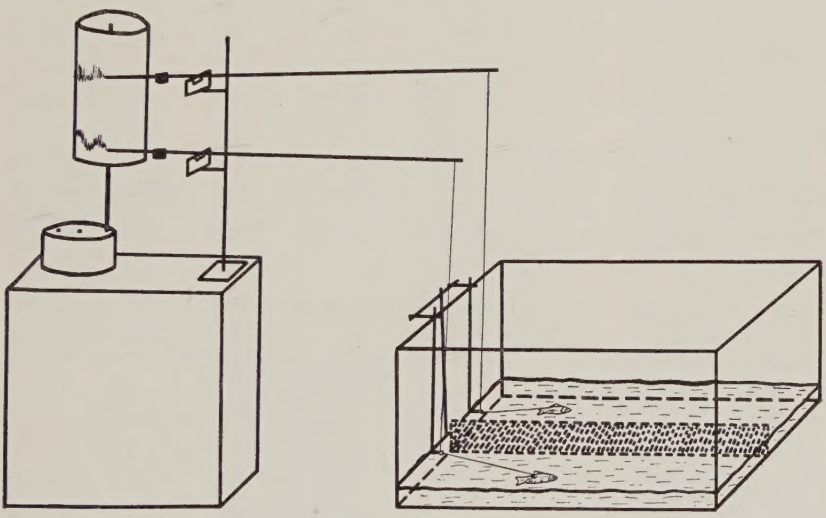


FIGURE 1

as the fish swims away from the end of the tank. Slack in the thread is quickly taken up as the fish swims toward the apparatus. The recording arm writes the record on a slow-kymograph. Time intervals of one hour were marked on the records taken. This was done in the early experiments by marking off the total time interval into parts of one hour when the record was removed, on the assumption that the drum revolved at constant speed. In later experiments an automatic timing device marking one hour intervals was used.

This apparatus not only records the total activity, but also the activity pattern, for in a long tank such as used the graphic record indicates the position of the fish in the tank at all times.

With fishes three inches or more in length direct observation shows that the fish swim about normally, feed and react to stimuli as do other fish in the aquarium. The "actograph" for fish devised by Szymanski consisted of a pulley-wheel suspended from a spring lever. Over the pulley-wheel ran a thread with a fish attached at one end and a weight at the other. This device gave only a rough measure of activity through the agitation of the lever caused by the thread running over the pulley-wheel, and did not record the activity pattern.

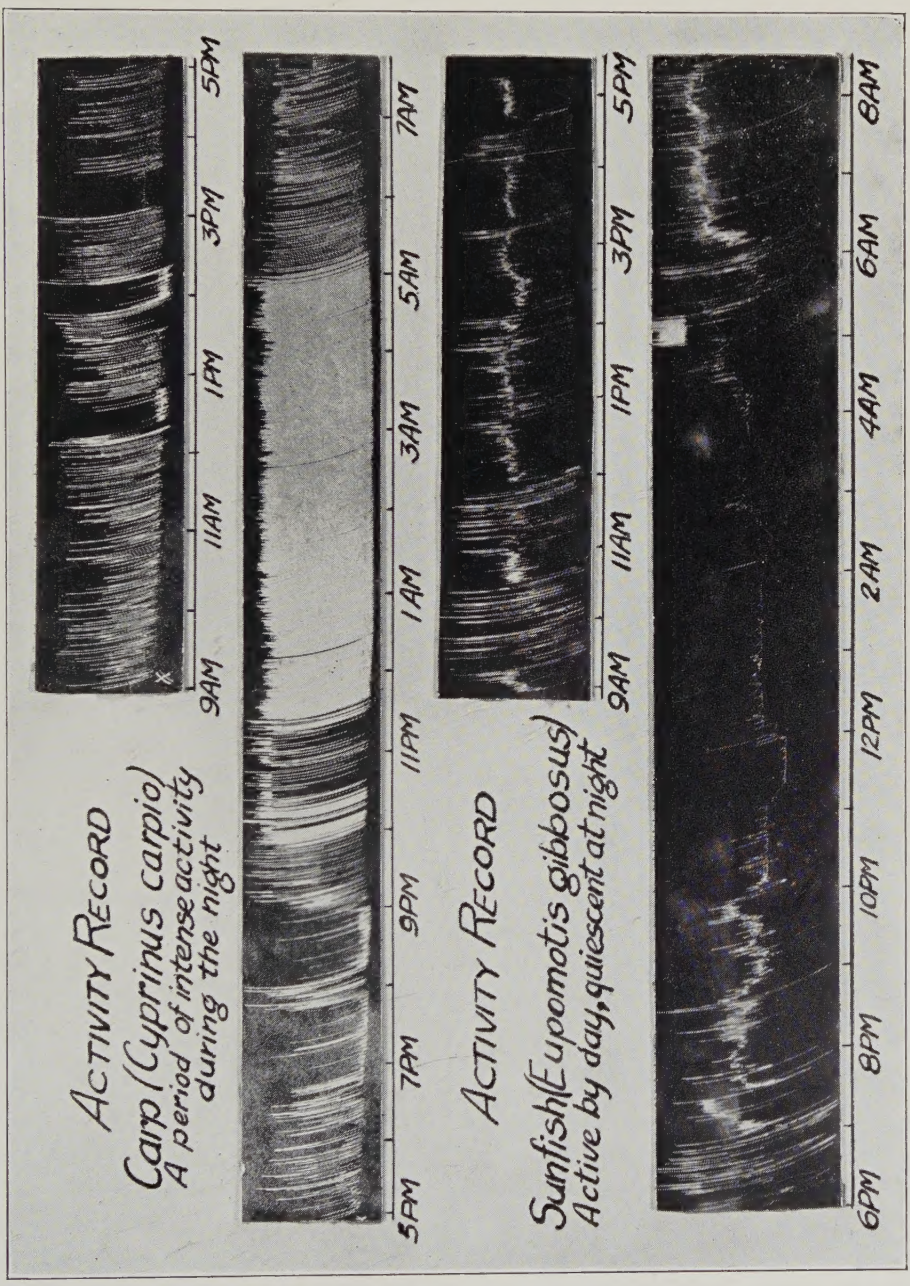
Polimanti (1911) made extensive observations on many of the marine fishes at the Zoological Station at Naples. His method, that of direct observation, is valuable in contributing to the knowledge of the habits and reactions of fish. Obviously it is not entirely satisfactory, particularly at night, where the use of light might conceivably disturb the normal behavior pattern.

Our data with experimental procedure involved can best be presented separately for each species or group of species studied: the Centrarchidae, the carp, the mud-minnow, the goldfish, and a few other fishes.

THE CENTRARCHIDAE

All records on the Centrarchidae were secured at the Stone Laboratory of the Ohio State University, Put-in-Bay, Ohio, during the summers of 1929 and 1932. The apparatus was set up in a dark basement room, with a little light filtering in during the day and temperature of about 21° C. The aquarium used was approximately 24 inches long, and divided by an opaque partition down the center into two tanks each about 7 inches wide. Water pumped from the lake circulated slowly through the tanks. The fish were fed on earthworms, crustacea and small fish and readily took food while attached to the apparatus.

Records were taken simultaneously on a rock-bass, *Amblo-plitus rupestris*, and a sunfish, *Eupomotis gibbosus*, from 6:00 P. M. July 20th to 8:30 A. M. July 23rd. A sample record of the sunfish is shown in Plate I. Throughout the experiment the sunfish was active by day. At night from about 8:00 or 9:00 P. M. until about 5:00 A. M. there ensued a period of almost total quiescence. The records of the rock-bass showed no such periodic fluctuation. This fish swam more than the sunfish at night and less by day. These data are of particular


ACTIVITY RECORD
Carp (Cyprinus carpio)
A period of intense activity during the night
9AM 11AM 1PM 3PM 5PM
5PM 7PM 9PM 11PM 1AM 3AM 5AM 7AM
ACTIVITY RECORD
Sunfish (Eupomotis gibbosus)
Active by day, quiescent at night
9AM 11AM 1PM 3PM 5PM
6PM 8PM 10PM 12PM 2AM 4AM 6AM 8AM

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interest in connection with what is known of the feeding habits of the two. Rock-bass may be caught at almost any hour of day or night, while it is not the usual thing to catch sunfish at night.

Two blue gills, *Lepomis pallidus*, approximately 6 inches long, were studied in July, 1932. Continuous records of two days duration were taken for each. These showed that both specimens swam day and night with no apparent diurnal variation, and that they were somewhat more active than the rock-bass.

Records on two large-mouth black bass, *Micropterus salmoides*, taken in July, one for a little over a day and the other for two days, showed continuous swimming with a period of lessened activity rather poorly defined between 1:00 and 5:00 A. M. The fish used were a little over 6 inches long.

Of the Centrarchids studied it may be concluded that the sunfish showed a very clearly defined 24-hour rhythm, the black bass a poorly defined one, rock-bass and blue-gills none. The sunfish was least active, the rock-bass intermediate, and blue-gills and black bass most active. The data are too fragmentary to be of much value in determining relative amounts of activity, but do give some information on the pattern for the different species.

THE CARP
(*Cyprinus carpio*)

During the summer of 1929 activity records were taken at the Stone Laboratory on three young carp each about 4 inches long. These were individuals from the spring hatch. The fish were kept in a still-water aquarium in a basement room, well lighted by day and with some artificial light entering at night until 10:00 P. M. from lights outside the laboratory. The tank was approximately 24 inches by 7 inches with water 4 inches deep. The temperature remained close to 21° C. with little fluctuation from day to night. The experiments on these fish covered a total period of 7 days and 13 hours during the latter part of July and early August. All records showed a period of intense activity during the night followed by lessened activity in the day. The carp at this age are very active night swimmers with a clearly defined monophasic pattern. A sample activity graph appears in Plate I. Table I gives the approximate times of the beginning and end of each period of hyperactivity.

Two larger carp, each 9½ inches long, were secured in the summer of 1932 and records taken on them over a period of about 4 days. These fish were a year older than the first ones used. In carp No. 4, the larger of the two specimens (greatest depth 3 inches) the record, continued over 43.4 hours, showed a total lack of the diurnal rhythm so apparent in younger specimens. Carp No. 5 (greatest depth 2¾ inches) showed a tendency to swim more by night than by day, but the cycle was not as well defined as in the younger fish. These records were taken in the latter part of July. The records indicate clearly a change in activity pattern with age in the carp. The

TABLE I

NOCTURNAL DRIVE IN YOUNG CARP

Fish No.	Begins	Ends	Duration in Hours
1	10:30 P. M. July 28	4:45 A. M. July 29	6.25
1	10:00 P. M. July 29	5:15 A. M. July 30	7.25
1	11:30 P. M. July 30	4:50 A. M. July 31	5.33
1	10:15 P. M. Aug. 1	4:15 A. M. Aug. 2	6.00
2	10:00 P. M. Aug. 10	4:45 A. M. Aug. 11	6.45
3	8:30 P. M. Aug. 11	8:30 A. M. Aug. 12	12.00
3	7:30 P. M. Aug. 12	6:20 A. M. Aug. 13	10.83
3	5:30 P. M. Aug. 13	6:30 A. M. Aug. 14	13.00

carp, often thought of as lazy and sluggish, when measured in terms of total movements over a long period, is among the most active of the fishes studied. This seems correlated with its foraging and omnivorous habits. Conceivably the shift in activity pattern may have to do with an adaptive mechanism in relation to predators.

THE MUD MINNOW

(Umbra limi)

Records on five adult mud minnows, 4 to 5 inches long, taken the last of July and first of August, 1929, at the Stone Laboratory, covered a period of 12 days, 2½ hours. The aquarium and other experimental conditions were the same as those used for the young carp. All of these fish were extremely sluggish during the day, lying by the hour without swimming the length of the aquarium. At night, however, a period of activity ensued which, while not intense, was well delimited from the rest of the day.

During the months of October and December ichthyograms were taken of mud minnows which had been carried from Put-in-Bay to the laboratory of Biology at Wooster. The experimental tanks were approximately 24 by 7 inches, of stone and with a sand bottom, in a basement room with temperature ranging from 17° C. to 24° C. Activity of three fishes covering 12 days and 20 hours was recorded. It was rather surprising that the fish were much more active than during the summer. Furthermore the pattern had entirely changed. There was no period of increased activity at night. If anything, the fish were more active by day.

During the course of a six-day experiment on mud minnow No. 6 a cover was placed on the experimental tank in such a way that the end of the tank farthest from the apparatus was darkened as contrasted to the other end. The graphs show clearly the gradual development of an activity pattern in response to this situation. On the first three days the fish was to be found about as frequently during the day hours in one part of the aquarium as in another. On the fourth day during the morning a rather marked "preference" for the dark end of the tank developed. Still there were frequent trips to the lighter end. During the afternoon the fish went only twice to the lighter end. But at 6:00 P. M. it started swimming the length of the aquarium and made many such excursions during the night. The next morning the fish remained at the dark end of the tank. The cover of the tank was carefully removed at 11:15 A. M. and replaced at 12:30 P. M. During this interval the fish swam the length of the tank 24 times. At 2:30 P. M. the cover was again removed and replaced at 3:45 P. M. In this interval there were 26 excursions the length of the tank. At 5:30 P. M. the fish again started swimming the length of the aquarium and continued intermittently until 7:30 A. M. Experiments on this day with removal of the tank cover were followed by similar results. Again at 5:30 P. M., about dusk, excursions the length of the tank began.

It is quite clear that the position of the fish in the aquarium was regulated by response to light stimuli. In fact one could determine quite well from these records the hours of dusk and dawn. The response of the fish when the cover was removed was in no case immediate, but occurred about two minutes after the change in light took place. During the course of experiments on mud minnows records were taken on three

specimens over periods sufficiently long to indicate that there is a change in total activity from day to day with the suggestion of a cycle of several days duration.

THE GOLDFISH
(Carassius auratus)

In the winter of 1932 activity records were secured for 5 goldfish varying in length from 4 to 6 inches. The experimental tanks in the Wooster laboratory were similar to those used for the mud minnow, but were not covered. Temperatures ranged from 17½° C. to 21° C. Water flowed slowly through the tanks during the experiments. The fish were fed once a day on dried entomostraca.

Between January 10th and February 17th a total of 39 days of activity records were taken of these 5 fish. Approximately 10 days' records were taken under continuous light, a 75-watt light bulb suspended 3 feet above the center of the experimental tank. The remainder of the records were taken under the natural light which entered the basement room.

Under natural light conditions the goldfish were, in general, more active during the day, and particularly during the hours from 1:00 A. M. to 6:30 A. M. there was a tendency to slow down. These findings are in accord with those of Szymanski (1914) for the goldfish. Continuous light of the intensity used served to reduce the total activity, and at the same time to distribute it more evenly over the 24 hours. However, the diurnal rhythm was not entirely eliminated after several days exposure to continuous light.

All of the ichthyograms on fishes No. 4 and 5 were taken under natural light conditions and they indicate that activity rises slowly to a peak over a period of several days' duration and then drops off rather suddenly to rise again. This rhythm in No. 4 consisted of a cycle approximately 6 days long and in No. 5 of a cycle 2 to 3 days long. It is clear from our records that activity in individuals cannot be properly compared and contrasted by taking records for one or two days only. Some of the records on Nos. 4 and 5 were taken simultaneously in parallel compartments under identical conditions and for a certain day one fish was more active and for another day the other was the more active. These long cycles of activity in fish are of particular interest in comparison with the findings of Richter (1927) on such cycles in rats.

Our experiments showed individuals differing from one another in total activity over periods covering the entire cycle, so that one goldfish might be described as sluggish and another as hyperactive. More striking than the variation in total activity was the tendency for certain individuals to develop an individual activity pattern. Three of the goldfish, Nos. 1, 3, and 5, swam during the night hours mostly at the end of the tank farthest from the recording apparatus. During the day their preference if any was for the other end of the tank. Fishes 2 and 4 showed no tendency to develop this particular activity pattern. The pattern referred to could be broken up

TABLE II

Activity Cycles in the Goldfish

Fish No.	Dates of Minimum Act.	Dates of Maximum Act.	Duration of Cycle in Days
1	Dec. 10	Dec. 14	4
1	Dec. 14	Dec. 19	5
2	Jan. 16	Jan. 21	5
2	Jan. 21	Jan. 26	5
2	Jan. 26	Jan. 31	5
2	Jan. 31	Feb. 6	6
2	Feb. 6	Feb. 11	5
2	Feb. 11	Feb. 16	5
2	Feb. 16	Feb. 22	6
2	Feb. 22	Feb. 28	6
2	Feb. 28	Mar. 6	7
2	Mar. 6	Mar. 10	4
2	Mar. 10	Mar. 16	6
3	Mar. 16	Mar. 20	4
3	Mar. 20	Mar. 25	5
3	Mar. 25	Mar. 29	4
3	Mar. 29	April 2	4

immediately by the use of continuous light. However, it is not understood why at dusk the far end of the tank was sought and occupied until dawn or a little after.

From December 11th, 1935, to March 23rd, 1936, Mr. William Kieffer and the author secured an extensive series of graphs of the activity of 7 goldfish totaling 4,326 hours recorded. These experiments were run in the same tank as those described above with the temperature at about 20° C. and seldom fluctuating more than two degrees from this. These fish were fed regularly once a day about .1 gram of imported oriental fish food. All grew during the course of the experiment and

there was no mortality except one accidental death due to a fish jumping out of the aquarium. This series of experiments corroborated the findings recorded above on individual variability in total activity and pattern of activity. All showed long cycles of activity lasting from 4 to 7 days. Some of the data on this point are given in Table II. Four of the seven fish showed a marked tendency to turn much more frequently to the right than to the left. Most of the fish generally came to rest with the tail under the eyelet of the recording apparatus. One rested with the head under the eyelet.

The data secured by Kieffer show a very definite relationship of activity to feeding. When the fish are well and regularly fed there is an intense activity period lasting from one to three hours after the food is placed in the tank. The fish actually consume the food in 15 minutes or less and the intense activity far exceeds this time. By covering the tank by day and lighting artificially at night and feeding at night the regular diurnal rhythm could be obliterated.

RECORDS ON OTHER SPECIES

Fragmentary records of a day or so were taken on the yellow perch, *Perca flavescens*, showing long periods of 15 minutes to an hour in which the fish remained motionless, interspersed with short excursions seldom more than the length of the tank and back, and often shorter. The record, totally different from that of carp, goldfish or the Centrarchidae, is probably typical of a darter, lying quietly on the bottom of stream or lake for a long time.

Records of the bull-head, *Ameiurus melas*, and the channel-cat, *Ictalurus* sp., also fragmentary, showed the former to be somewhat more active than the latter. Neither showed much difference between day and night swimming, certainly no clearly defined rhythm as in sunfish and young carp.

SUMMARY AND CONCLUSIONS

The author presents these data as a preliminary study of behavior patterns in fresh-water fishes. He is fully aware that the experiments are not complete, and that many factors could be more carefully controlled and studied. However, the data here presented indicate some of the problems which might further be investigated and the possibilities of the ichthyometer as a tool for their study.

Obviously it is impossible to have published all of the graphic records secured, which total over 200 yards of material and represent more than 100 swimming miles. It seems unwise even to include adequate samples of all the points covered. Rather we have chosen to publish one plate to illustrate the nature of these ichthyograms.

The findings reported here may be summarized as follows:

1. By the use of the ichthyometer it is possible to take continuous quantitative records of the total activity of various species of fish over long periods of time and under a variety of conditions planned by the investigator.

2. Fish show either a fairly continuous pattern of activity over a 24-hour period or a monophasic one conditioned apparently by reaction to light. There is no indication of any well defined short-period rhythm such as reported for rats and birds.

3. Certain fish are active by day and quiet at night; other species show the reverse pattern.

4. There appear to be marked seasonal and age differences in the activity pattern of certain species.

5. Individuals of a species show marked variations both in the intensity of their activity and in its pattern, so that it may be stated that the individual pattern is superimposed on the racial one.

6. Long cycles of some days duration leading gradually to a peak of activity followed by a sudden drop to a minimum and subsequent rise have been shown to occur in goldfish and seem to be present in the mud minnow. Records of other species studied do not cover periods long enough to furnish data on this point.

7. Light intensity and time of feeding definitely affect activity. The response to both of these stimuli outlasts by an appreciable length of time the application of the stimulus. In the mud minnow it has been shown that the application of certain light stimuli is followed by a latent period of a minute or more before the swimming reaction occurs.

ACKNOWLEDGMENTS

The writer wishes to express his grateful appreciation to the following persons:

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3. Dr. R. V. Bangham, for co-operation in the work carried on at the Wooster Laboratory of Biology.

4. Miss Laura Blon and Mr. William Kieffer, undergraduates at Wooster, who secured many of the graphic records on goldfish.

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Modern Inorganic Chemistry

After searching long and arduously for a book suitable as a text in a course in advanced inorganic chemistry, it is pleasing to find one which serves that need admirably. The authors depart entirely from the practice, too long followed in this field, of presenting a dictionary or encyclopedia of chemical compounds, their properties, preparation, and uses. Instead the authors believe that "it is more illuminating to deal with related compounds and special topics, which provide, as it were, a cross-section of the subject. To take a case in point, it is more instructive to treat the hydrides as a related group than in isolation, as compounds of the parent elements." The wisdom of this view is amply demonstrated.

To anyone, student, teacher, or research worker, desiring a thoroughly up-to-date treatment of the theories of inorganic chemistry together with a resumé of recent advances in the knowledge of the elements and their inorganic compounds, Emeleus and Anderson may be recommended without hesitation. The amount of information assembled here is astonishing. While it is hardly possible to mention all topics discussed, some idea of the breadth of the work can be seen from the chapter titles: atomic structure and the periodic system, atomic weights and isotopes, structure of molecules, co-ordination compounds and inorganic stereochemistry, poly-acids and silicates, hydrogen and the hydrides, free radicals of short life, non-metallic oxides, recent chemistry of the non-metals and of the metals, peroxides and per-acids, metallic carbonyls and nitrosyls, intermetallic and interstitial compounds, reactions in liquid ammonia and liquid sulfur dioxide, and radioactivity and atomic disintegration.

No work of this kind can be "easy" reading in its entirety, but this book is remarkably so. Typographical and factual errors are few.—*W. C. Fernelius.*

Modern Aspects of Inorganic Chemistry, by H. J. Emeleus and J. S. Anderson. xi+536 pp. New York, D. Von Nostrand Co., 1938. $9.00.

THE NUMERICAL STATUS OF SOME MAMMALS THROUGHOUT HISTORIC TIME IN THE VICINITY OF BUCKEYE LAKE, OHIO[1]

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While examining literature for references to the flora, avifauna and general conditions throughout historic time[2] in the vicinity of Buckeye Lake, Ohio, for my report upon the birds of that area, I collected data on the numerical status of several mammal species. Between the years 1922 and 1935 I interviewed many of the old residents of the Buckeye Lake area and obtained their impressions of the time of disappearance or numerical changes in abundance of several mammal species during the period from 1860 to 1935. Between 1922 and 1933 I also made personal observations upon several mammal species.

Before proceeding with the mammal records it is necessary to give a brief history of the changes which have taken place in the vicinity of the present Buckeye Lake. Gist (1893: 42), Smith (1870: 21) and others have indicated that before 1800 the area now covered by the waters of Buckeye Lake was a "Great Swamp." This swamp contained one or more small glacial lakes which were surrounded by cranberry-sphagnum-red maple bogs, considerable brush, and swamp forests of the elm-ash-soft maple type. Extending immediately northwest of the "Great Swamp" was another which later became known as "Bloody Run Swamp." This latter swamp extended to the present site of Kirkersville and contained a mixture of cranberry-sphagnum-red maple-poison sumac bog-swamps, alder-red ozier brush communities, and swamp forests of the elm-ash-soft maple-pin oak type. The adjacent country northeast, east and south of the present Buckeye Lake was principally rolling upland, with glaciated hills less than one hundred and fifty feet in height. The better drained portions of the uplands contained tall forests which seemingly were principally of the oak-hickory-hard maple-chestnut type (Smith, 1870: 20 and Schaff 1905:

[1]For information concerning the flora, avifauna and general conditions in the Buckeye Lake area during historic time see my forthcoming report on "The Birds of Buckeye Lake, Ohio," *Misc. Publ., Mus. Zool., Univ. Mich.*

[2]For the region under treatment historic time extends from January, 1751, to the present.

82–89). The less well-drained lower slopes and intervales contained a beech-maple forest type. The writings of Smith (1870: 21 and 168), Hill (1881: 199) and others indicate that the Great and Bloody Run swamps and adjacent uplands were a favored hunting ground of the Indians before 1800, and that two important Indian trails passed beside this hunting ground.

The Great and Bloody Run swamps and adjacent uplands, hereafter referred to as "the Buckeye Lake area" or "the area," was little affected by the white man until after 1800. The settling of the area, removal of the forest, and cultivating of land (particularly uplands) became pronounced shortly after 1800, and by 1820 several towns, such as Newark (1802), Granville (1806), Thornville (1815), Lancaster (1800), and Somerset (1807), had been established. Drastic changes in the Great Swamp began in 1826 with the building of the canal and the "Old Reservoir." The reservoir was filled with water in 1830, thereby eliminating most of the Great Swamp. In 1836 construction was begun on the "New Reservoir," immediately west of the first one, and it was filled with water a few years later.[3] The building of the National Road across the northern edge of the area was started in 1825 and completed a few years later. The canal, reservoirs, and National Road greatly hastened the settling of the country, the removal of the forests, and the general modification of the topography. By 1840 the forests of the uplands had been cut over, the Great Swamp was water-covered, and only the Bloody Run Swamp remained in a more or less primitive state.

Changes were almost as drastic during the period from 1850 to 1900 as in the preceding fifty years. In 1855 the third major method of transportation, the railroads, was added. All three agencies of transportation greatly increased the accessibility of the area, opened markets for farm produce, and in general caused an ever increasing amount of forest and brush removal. During this period attempts were made at draining portions of the hitherto inaccessible Bloody Run Swamp.

The operation of interurban electric lines beginning in 1901 considerably increased the number of persons annually visiting the area, and also augmented the amount of hunting. By 1914 the automobile had become a profound influence in modifying

[3]The reservoirs were first known as the Licking Summit Reservoirs, later as Licking Reservoir; in 1894 an Act of the Legislature changed the name to Buckeye Lake.

the roads and all other features of the area, besides greatly increasing the number of visitors. Between 1900 and 1930 the Bloody Run Swamp, the last partially unmodified section, was almost entirely drained, de-brushed and deforested. The final result of deforestation, de-brushing, draining, flooding and cultivating, and the making accessible of the land to large numbers of people has resulted in (1) the entire elimination of the "Great Swamp" and the creation of the present Buckeye Lake, (2) removal of all forests except secondary remnants, and (3) draining and cultivation of the Bloody Run Swamp until today its once distinctive flora and fauna is essentially that of the immediately adjoining region.

CHANGES IN NUMERICAL STATUS OF SOME MAMMALS

American Elk (*Cervus canadensis canadensis*) was recorded as late as 1755 by Smith (1870: 20–21) and were perhaps present until a few years later.

Several Bison (*Bison bison pennsylvanicus*) were killed in this area or the immediate vicinity in 1755 (Smith, 1870: 21). According to Smith the species was quite numerous in eastern Ohio between 1755 and 1759, and was much hunted.

American Beaver (*Castor canadensis*) was probably present in 1755. While traveling with the Indians in the general vicinity of Buckeye Lake, Smith (1870) frequently observed the trapping and catching of beaver. Schaff (1905: 113–114) mentioned the existence of a beaver dam "about three feet high and seventy-five feet long," and beaver meadow, which he saw a few miles east of Kirkersville when he was a boy (1840–1858). Schaff (104) had "no doubt" that Bloody Run Swamp was enlarged by beavers damming Bloody Run, but gave no evidence to support this theory. He was "inclined to think" that beaver "disappeared with the Indians or perhaps sooner." The early extinction of the beaver, bison, and elk may not have been entirely the work of the white man, since some of the Indians of eastern Ohio had guns and steel traps during the early years of the eighteenth century. Smith (1870: 24 and 60) repeatedly mentioned that the Indians used guns and steel traps between 1755 and 1759. Schaff (1905: 116–117) suggested that "as soon as fire arms were substituted for bows and arrows, and steel traps for simple wooden devices and dead falls, the destruction of game must have gone on rapidly." Possibly over-hunting by Indians, or Indians and white men, caused the elk, bison and

beaver to disappear in the area before the pioneer farmer and his destruction of primeval conditions became a factor.

Panthers (*Felis concolor couguar*) are frequently referred to in the literature but generally it is not clear whether the name "panther" refers to this species or the bobcat. *Felis concolor couguar* was in the general vicinity of the area in 1805 and was probably in the Great and Bloody Run swamps for several years thereafter. Smucker (1876: 45) related that in the autumn of 1805 Jacob Wilson, who was then living within a mile of Newark, treed with his dogs and then killed a "huge panther" that had previously raided his pig pen and carried away a pig. Brayton (1882: 8) considered this animal to have been *Felis concolor.*

Bobcats (*Lynx rufus rufus*) are indicated by the literature references as probably having been rather numerous, and they presumably remained in the large wooded and swampy areas after the panther had been extirpated. However, no reliable data of the actual capture of the bobcat in the area has been found. Many of the older residents claim that their fathers killed bobcats in Bloody Run Swamp as late as 1860. Schaff (1905) did not mention this species as occurring between 1840 and 1858.

American Otter (*Lutra canadensis canadensis*) was mentioned by Hill (1881: 176) as occurring in "considerable numbers" in the swamps of Licking County in early historic times. Kirtland (1838: 176) stated that it was common in Ohio as late as 1838. Schaff (1905: 97) related that between 1840 and 1858 "Otter tracks were often seen in the snow as they crossed to and from the Reservoir [Buckeye Lake] to the creek [Bloody Run]."

Black Bears (*Euarctos americanus americanus*) are mentioned in many undated references. They were apparently present until at least 1825 and possibly as late as 1840 (Hill, 1881: 176; and Graham, 1883, Pt. 5: 13). Schaff (1905: 91) claimed that bear, as well as beaver, buffalo, elk and deer had disappeared before his time (1840–1858). Graham (1883, Pt. 5: 314) stated that "Bears were very numerous about the original lakes and swamps. Indians and whites alike made it a business to hunt and kill them. In very early time, bears from other parts of the county were chased into the swamps and lowlands, where the Reservoir [Buckeye Lake] now is. They could not always be followed up successfully, and sometimes their capture had to be given up." Like the Indians before them, the early pioneers

considered the bear an important article of food. With the introduction of live stock and cultivation of crops the bear and other once important food animals became "vermin." Consequently methods were employed to decrease their numbers or extirpate them from the area. One method of reducing their numbers was through community or circular hunts such as were described by the Rev. Timothy Howe (Schaff, 1905: 148–152; and Smucker, 1876: 49–52) and Samuel Park (Hill, 1881: 604). One of these hunts, which took place between 1823 and 1825, was most graphically described by Howe. He related that a tract of land which embraced "Gibbon's Deadening"[4] in Harrison Township, Licking County, was chosen for a hunt. Shortly before the actual hunt was to take place the Surveyor of Licking County surveyed the area to be hunted and outlined it by blazing trees. On the day of the hunt, most of the people of the community for miles around came to the deadening, and after all had assembled, the members of the party were placed in a line which completely encircled the area to be hunted. Some of the hunters were on horseback while the remainder were afoot, and at a signal, the entire assemblage began to march toward a given center, driving the game before them. When the circle became sufficiently small, the better marksmen were sent into the circle to shoot whatever game it might contain. At this particular hunt the bag consisted of "one large black bear, three wolves, forty-nine deer, sixty or seventy turkeys, and one owl" (Schaff, 1905: 151).

Timber Wolves (*Canis lupus*) were frequently mentioned, and were indicated as present in 1823 (Schaff, 1905: 151) and probably for several years thereafter. Hill (1881: 176) wrote that a bounty of as much as four dollars was paid for the scalp of a large wolf, according to the record of the Licking County Commissioners. Graham (1883: 201) states that in 1815 a den of cub wolves was captured in Hopewell Township, Perry County.

White-tailed Deer (*Odocoileus virginianus*) were unquestionably very numerous until at least 1825, and are frequently mentioned in the literature (Hill, 1881: 176; Graham, 1883,

[4]A "deadening" was a section of forest in which the trees had been girdled, causing them to die. After the trees had been dead for several years, and many of their limbs had fallen off, the dead timber was chopped down or burned and the land cleared of logs and brush, preparatory to farming. In the interim between the girdling of trees and clearing of land, a brush-thicket habitat invaded the area, providing excellent cover for the larger mammals.

Pt. 3: 15 and Pt. 5: 314). Schaff (1905: 151) recorded the killing of forty-nine deer in the "vermin drive" related above. He also stated (p. 91) that deer had disappeared from Bloody Run Swamp before his time (1840–1858). However, the older residents who were interviewed claimed that deer were present in Bloody Run Swamp until about 1855.

Raccoons (*Procyon lotor lotor*) were apparently very numerous throughout all of central Ohio, for they were mentioned as frequently as the deer. Smith (1870) repeatedly touched on the abundance of raccoons in eastern Ohio between 1755 and 1759, and indicated that the Indians trapped them in large numbers. Schaff (1905: 97) stated that "raccoons and opossums were numerous" during the 1840 to 1858 period. The old market hunters and sportsmen claim that the raccoon was more diurnal in early historic times than it is today. As late as 1885, according to these men, one to twelve raccoons could be killed per day during late summer by walking along the banks of streams and shooting them as they searched for crayfish and other food. The men also stated that there has been a rather steady decrease in the numbers of raccoons from 1885 to the present day, coincidently with the decrease in size and amount of forest remnants, and a reduction in the number of large den trees. This decrease in raccoon numbers has occurred in spite of ever increasing restrictions in hunting.

The Gray Fox (*Urocyon cinereoargenteus cinereoargenteus*), a woodland inhabitant and seemingly a rather stupid animal, was apparently very common in early historic time. Its abundance and the absence or extreme scarcity of the red fox in those times is frequently mentioned in early Ohio literature. Kirtland (1838: 176) stated that the gray fox was "very abundant" at the coming of the white man, and that it disappeared "before the advancement of civilization." Of the red fox he wrote that it "was unknown in this region of country [Ohio] until the introduction of the white population," but that by 1838 it had become "a common and troublesome inhabitant." The older residents give the time of final extermination of the gray fox in the Buckeye Lake area as between 1855 and 1875. Writing of his experiences in Bloody Run Swamp between 1840 and 1858, Schaff (1905: 97) states that by that time gray foxes had disappeared.

The Red Fox (*Vulpes fulva fulva*) was apparently very rare in early historic time. In relating his experiences while hunting

the red fox (on horseback and with packs of hounds) in the area and vicinity, Schaff (1905: 97) gave the impression that this species was numerous between 1840 and 1858. William Harlow, Stephen Holtzberry, and other old residents have informed me that this inhabitant of the field-brush-remnant forest community was very numerous during the period from 1860 to 1900 but that it has since decreased in numbers. A few considered the decrease as great; others thought it was rather slight.

Gray Squirrels (*Sciurus carolinensis*) were not definitely recorded in the area before 1820, but it is assumed that this forest-inhabiting species was present from 1751 to 1820 and possibly was as abundant then as it was between 1823 and 1875. Schaff (1905: 97) mentioned that black squirrels (presumably a phase of the gray squirrel), gray squirrels, and flying squirrels (*Glaucomys volans volans*) were "in every wood" during his boyhood (1840–1858). By 1807 (Jones, 1898: 168) this squirrel had become such a nuisance to the farmer that the Ohio Legislature passed an Act requiring every person within the state, subject to payment of tax, to furnish a specified number of squirrel scalps within a given period (tails were usually substituted for scalps). If the evidence of kill was not produced the penalty was the same as that for a delinquent tax payer. Despite this persecution the squirrels "ocasionally" became exceedingly numerous.

One method of reducing the number of gray squirrels was by competitive hunts. Such hunts were frequently comprised of two companies or sides and the company killing the greatest number of animals usually won a prize. Hill (1881: 605) mentioned such a hunt which occurred in 1822, when for a day and a half, one group hunted in Granville Township, Licking County, and the other in Union Township (in the Buckeye Lake area) of the same county. In this hunt only rifles were used and the result was the killing of more than 3,800 squirrels (a little over nineteen hundred on a side). This number seems very large, but does not compare with the incredible number killed in the famous Franklin County squirrel hunt of August 10, 1822. It is claimed that in this hunt, which lasted a day, about two hundred men killed 19,650 squirrels (Jones, 1898: 172; and Hill, 1881: 605). Despite the persistent persecution and hunting of gray squirrels their numbers remained very large in the Buckeye Lake area, according to the old residents, until about

1880. After 1880 the forest remnants became too small and isolated to support the former large numbers and a decided decrease began. By 1910 the status of this squirrel had changed from that of a nuisance to that of a sporting game mammal. Despite ever increasing restrictions on its capture, the species disappeared from the area before 1920. The late game protector Earl McPeak told me that the last gray squirrel he saw, which had been killed in the area, was taken in the fall hunting season of 1918. During my investigations in the area between 1922 and 1933 I saw none and heard of no one who had seen any. Despite much persecution this animal remained immensely abundant as long as the environmental factors were sufficient. It became extirpated from the area when the amount of available habitat was at its lowest ebb, although the animal itself was receiving the greatest amount of legal protection from hunting and persecution that it had at any period of historic time.

Fox Squirrels (*Sciurus niger rufiventer*) were originally rare or absent over large areas of Ohio. The absence of references to this squirrel in early Ohio literature forces one to this conclusion. Schaff (1905) gave no indication of the presence of the animal between 1840 and 1858, although he frequently mentioned other squirrel species. The older residents of the area do not remember this conspicuous species between 1860 and 1870. Some claimed that it appeared in the area about 1875 and that it showed a rather consistent increase in numbers until 1900 to 1910. After 1915 a slight decrease was noted. These statements seem plausible when it is remembered that the fox squirrel is chiefly an inhabitant of grove-like forests (often an oak-hickory association) of rather small extent, surrounded by brush or cleared land. Such conditions were unusual before 1825, increased greatly in amount between 1830 and 1900, and began to decrease after 1900. During my investigations from 1922 to 1933 the fox squirrel population of the Buckeye Lake area showed a decrease, which was coincident with the continued removal of the remnant forests and the over-grazing of the woodlands. In this period hunting was judged to be of less importance as a detrimental agent than were other factors.

Cottontails (*Sylvilagus floridanus mearnsii*) were apparently of little importance to the early pioneers, for the early records of rabbits in the area are few and vague. Curiously, Schaff (1905) did not mention the rabbit in his recollections of the area

between 1840 and 1858. Despite the lack of definite records it seems safe to assume that the species was present before 1800, at least about forest edges, in brush lands, and in forest openings. Obviously this inhabitant of open, woodland remnants, brushlands and fields must have greatly increased in abundance with the augmentation of favorable conditions. The old residents have informed me that despite much trapping, hunting and other persecution the cottontail was very numerous during the period from 1860 to 1895, especially in the occasional or cyclic "rabbit years;" and that by 1910 the cleaning up or grazing of woodlands, brushlands and fields, and draining of swamps, had resulted in a decrease in numbers. This decimation has continued, in spite of increased protection. I noted a gradual decrease between 1922 and 1933. In this period the rabbit became rather uncommon on the most over-grazed and highly cultivated farms, and especially in the uplands where the fertility of the soil was low.

Muskrat (*Ondatra zibethica zibethica*) was surely present about the original glacial lakes and swamps of the area, although there is a lack of definite early records. Writing of conditions between 1840 and 1858, Schaff (1905: 97) mentioned that "along Bloody Run and Licking [South Fork of Licking River] muskrats abounded." By 1850, after completion of the reservoirs and the subsequent establishment of large cattail marshes, the species had probably become very numerous. According to the old residents this mammal was abundant during the period from 1860 to 1910, and the trapping of the animal for its fur was the principal occupation of several men during the latter half of the period. The residents state that muskrats have become reduced in numbers in recent years coincidentally with the decrease in area of marshland, and in spite of increased hunting restrictions. Between 1922 and 1933 I observed the draining of several swamps and marshes, by which the amount of available habitat in the area was materially reduced and the number of muskrats was consequently decreased.

Nothing has been found concerning the abundance of mice in the area in early historic time, although mouse concentrations have been mentioned in early literature for other sections of Ohio. The Field Mouse (*Microtus pennsylvanicus pennsylvanicus*) and the Northern Deer Mouse (*Peromyscus leucopus noveboracensis*) are no doubt the species principally referred to. During several years in the period from 1922 to 1933 I noted

marked concentrations of mice, usually in isolated areas of 50 acres or less. The farmers claimed that they first heard of or began seeing these concentrations about 1915, that they were increasing in size and numbers, and that they were not of yearly occurrence.

GENERAL CONCLUSIONS

Several conclusions can be gleaned from these mammal records. The elk, bison, and beaver became rare or were extirpated from the area coincidentally with the coming of the white man. The use of guns and steel traps by the Indians seems to have been a determining factor in the early elimination of these species.

The black bear, white-tailed deer, timber wolf, otter, panther, and bobcat were present between 1751 and 1820. They were extirpated from the area between 1820 and 1850, contemporaneously with the flooding of the "Great Swamp," the beginning of the destruction of Bloody Run Swamp, and the removal of the upland forests.

Such medium-sized mammals as the raccoon, gray fox, and gray squirrel which were inhabitants of the forest or were tolerant of forest conditions, are at present greatly reduced in numbers or have been extirpated.

Mammals that are not chiefly forest inhabitants, such as the fox squirrel and rabbit, are assumed not to have been numerous before 1825; to have increased greatly with a moderate deforestation and the establishment of much brushland and fields; to have reached a climax in abundance during the period from 1850 to 1900 when such conditions were most prevalent; and to have decreased in numbers with the advent of over-grazing and modern "cleaning up" farming.

This study of the literature and unpublished data suggests that the large, wide-ranging, chiefly forest inhabiting species were first extirpated; that the forest-brush inhabiting, moderate-sized species were next extirpated; and that species of the open woodlands, brush and fields occur at present. We therefore postulate that the modifications in topography and flora made by the white man throughout historic time have been reflected in the changing numerical status of the mammalian species. With few possible exceptions the numerical increase or decrease of a species closely followed the increase or decrease

in the amount of its habitat,[5] except in so far as the species was unduly hunted or persecuted. If the species was not given sufficient protection it became exterminated before its environment was destroyed.

[5]Species having cyclic abundance probably do not show the effects of changing environment as rapidly as do non-cyclic species, but the general trend is the same.

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Newton

It is not infrequent that the private lives of many of the eminent scientists of the present and the past escape us entirely although their works occupy a prominent place in our daily existence. *Isaac Newton*, a biography of the author of the theory of gravitation, written by J. W. N. Sullivan and completed just briefly before his death, gives to the reader an interesting glimpse into the life of the great scientist. It reveals in an interesting manner how, in addition to being an indisputable scientific genius, Newton also was a most ourstanding and noteworthy character in his private life. This sketch is well worth devoting a few hours to and can be recommended to the reader interested in the history of science.

—*H. H. Nielsen.*

Isaac Newton, by J. W. N. Sullivan. New York, The Macmillan Co., 1938.

REPORTS ON THE FLORA OF OHIO. I

Notes on the Ohio Violets with Additions to the State Flora*

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A recent study of the violets in the Oberlin College Herbarium disclosed specimens of a number of species, varieties and hybrids from Ohio, which extend the previously known ranges in the state, have not been reported from the state, or have not hitherto been described. In this report the species already listed from the state are prefixed by the serial number used by Professor Schaffner in his "Revised Catalog of Ohio Vascular Plants," 1932, and in his later additions in the Ohio Journal of Science. Varieties or forms of these species, newly reported, have the serial number with the letter a, b, or c suffixed. Many of the plants are authenticated by Dr. Ezra Brainerd. In each such case, the county from which the specimen came is marked with an asterisk (*).

963. *Viola canadensis* L.

Professor Schaffner records this from "Eastern and Southern Ohio, northwestward to Huron, Fairfield, Highland and Hamilton." All of these counties except Huron lie South of an east-west line through Columbus. The Oberlin Herbarium extends the range northward into Muskingum,* Licking,* Lake,* Cuyahoga,* and Lorain.* H. L. Jones, on the label of the Licking County specimen, collected in 1889, wrote, "Rare in Granville."

963b. *Viola canadensis* L. var. *pubens* Farwell.

This differs from the "essentially glabrous" plant by being "hirtellous throughout." It was described by O. A. Farwell from Washington, Mich., in Papers Mich. State Acad. Sci. II: 34 (1922) 1923. It has not been reported from Ohio, but should be looked for in the northwestern part of the state.

964. *Viola eriocarpa* Schw.—*V. scabriuscula* Schw. mss.

This was described by Schweinitz (1822) from plants growing abundantly in rich meadow bottoms near Salem, North Carolina. All of the plants had densely white-villose capsules. In 1837 Wm. Darlington, Fl. Cestrica, p. 147, described this species, "growing in moist woodlands, along the Brandywine" in Pennsylvania, as having "the

*Papers from the Department of Botany, Oberlin College, No. 2.

capsule sometimes quite naked, often densely villose." Since then the capsule of *V. eriocarpa* has been described as "glabrous or tomentose," Britton, Man.; "woolly or sometimes glabrous," Britton and Brown, Ill. Fl.; "as in the preceding (*V. pubescens*)," Gray, Man. 7th ed.

Not until 1921 was the form with "ovaries and capsules glabrous" formally segregated under the name *V. eriocarpa* Schw. var. *leiocarpa* Fern. & Wieg., Rhodora 23: 275–276. 1921.

Professor Schaffner lists *V. eriocarpa* Schw. as of "general" distribution in Ohio, but he does not segregate var. *leiocarpa* Fern. & Wieg. from *V. eriocarpa* var. *typica*, with capsules densely villous.

964a. *Viola eriocarpa* Schw. var. *typica*.

A recent examination of *V. eriocarpa* in the State Herbarium yielded only nine specimens of this variety. These were from Ross, Warren, Delaware, Crawford, Richland, Huron, and Coshocton. To these Oberlin Herbarium adds Columbiana and Richland. There are no specimens in either herbarium from the western part of the state. The herbarium of Miss E. Lucy Braun adds Hamilton.

964b. *Viola eriocarpa* Schw. var. *leiocarpa* Fern. & Wieg.

This variety, on the contrary, has a state wide distribution. State Herbarium has it from 23 counties, and the Oberlin Herbarium from 6 other counties. Of these 29 counties, 17 are within the Appalachian plateau and the sandstone-shale region bordering it. Two counties, Franklin and Huron, lie in the transition zone, while 10 counties are in the limestone area of the western half of the State.

965. *Viola pubescens* Ait.—*V. pennsylvanica* Michx.

Aiton's description of this species (1789), Michaux's description of his *V. pennsylvanica* (1803), and Pursh's account of *V. pubescens* (1814) were all very brief, and were limited to habit and vegetative characters. They all described the plants as villose-pubescent, but none of them referred to the ovaries or capsules.

Thomas Nuttall, Gen. N. Am. Plts. I: 150, 1818, seems to have been the first to record the fact that some plants of *V. pubescens* have glabrous capsules, while others have capsules densely villous. He accepted the plant with smooth capsules as the type of Aiton's *V. pubescens*, and described the plant with villous capsules as a new variety under the name *V. pubescens β eriocarpon*. His differentiation of the two forms is as follows: "15. *V. pubescens*, *V. pennsylvanica* Mich. Leaves either very pubescent, or nearly smooth, subserrate; stipules ovate, mostly entire; fruit smooth," and "*β eriocarpon*, Fruit densely villous; stipules smaller. In fruit this would be taken for a distinct species, as the character is constant; in any other respect it does not materially differ from *V. pubescens;* both these varieties are abundant near Philadelphia."

Schweinitz in his monograph of the North American species of Viola, Am. Jour. Sci. 5: 48–81, 1822, describes *V. pubescens* as "*capsulis* glabris (Nuttall; *etiam villosis*)," and concludes that "the var. *β eriocarpon* of Nuttall is not my *eriocarpa*, but really a variety of *pubescens*."

O. A. Farwell, Papers Mich. Acad. Sci. 2: 33, 1922, treats the plant with "woolly capsules" as a mere form under the name *V. pubescens* forma *eriocarpa* (Nutt.) Farwell.

Most botanists, however, have not followed Nuttall, Schweinitz and Farwell in segregating the plant with woolly capsules as a distinct variety or form. They have been content to describe *V. pubescens* as having "Capsules glabrous or woolly," Gray Man. 7th ed.; "capsules glabrous or tomentose," Britton Manual; "capsules glabrous or sometimes woolly," Britton and Brown, Ill. Fl. 2nd ed.; while Fr. Marie-Victorien in his Flore Laurentienne, p. 281, 1935, says, "fruit glabre." On the other hand, H. D. House, N. Y. State Mus. Bull. 243–244: 50, 1923, and Bull. 254: 510, 1924, has not accepted Nuttall's and Schweinitz' concept of Aiton's species. He takes Nuttall's variety *eriocarpa* as the type, and treats the plant with glabrous capsules as the variety, giving it the name var. *peckii* House. A letter to Mr. House, asking the basis for his treatment of the two forms, elicited the following reply: "Several years ago, just how many I cannot now say, the late Dr. E. L. Greene informed me that the type of *Viola pubescens* was the form so common in the east with woolly capsules. I do not know the source of his information and rather doubt if he ever saw the type, if it still exists." Fortunately, Mr. C. A. Weatherby of the Gray Herbarium was to be in England during the summer of 1937, and kindly offered to examine Aiton's plants, preserved at the British Museum, in the hope that the type specimen of *V. pubescens* might be among them. His report, July, 1937, was as follows: "The type specimen of *Viola pubescens* Aiton, preserved at the British Museum, has pubescent ovary and capsule." *V. pubescens* var. *eriocarpa* Nutt. is, therefore, a synonym of *V. pubescens* Ait., while *V. pubescens* Nutt., and Am. auth., is a synonym of *V. pubescens* Ait. var. *peckii* House.

Professor Schaffner in his Catalog of Ohio Vascular Plants has followed the common usage and treated *V. pubescens* as a unit. However, a recent examination of the specimens referred to *V. pubescens* in the State Herbarium shows that both forms occur in Ohio.

965a. *V. pubescens* Ait. var. *typica.*

This is represented from 12 counties, viz.: Ashtabula, Lake, Huron, Wood, Lucas, Medina, Stark, Hardin, Morrow, in the northern half of the state, and from only Fairfield, Warren, Jackson, in the southern half. To the northern section the Oberlin Herbarium adds Cuyahoga, Lorain, Erie, and Richland. Univ. of Michigan Herbarium adds Hancock.

965b. *V. pubescens* Ait. var. *peckii* House.

This is represented in the State Herbarium from only three counties, viz., Franklin, Coshocton, and Scioto. The Oberlin Herbarium adds Lorain. Miss E. Lucy Braun's Herbarium adds Hamilton.

966. *Viola hastata* Michx.

This has been reported from five counties in the northeastern and eastern part of the state. To these add Trumbull,* Ashtabula,* and Lorain.* It is known in Lorain County only from one very limited

area, a few rods across, in "Bennett's Woods," Carlisle Twp., in the sandy alluvial soil of a very low rise in woods near Black River.

970. *Viola rostrata* Pursh.

Professor Schaffner says, "Rather general; but no specimens from the southwestern counties." Oberlin College Herbarium extends the range into Butler County, and has specimens from Erie, Lorain, Lake,* Columbiana,* Wayne,* and Licking.*

970a. *Viola rostrata* Pursh forma *trirostrata*, n. f., petalis lateralibus postice porrectibus vel rostratibus.

Lateral petals posteriorly lengthened or rostrate.—Occasional in open woods with the type, Russia and Amherst Townships, Lorain County.

This form was discovered in 1900 by Mr. Addison Gulick, a student in Oberlin College, in an open beech-maple grove on a terrace of Plum Creek, east of Oberlin. At that time he found five plants of *V. rostrata* with all of their flowers trirostrate, the spurs of the lateral petals being of approximately the same length as the spur of the nectary. With these were a number of plants having both trirostrate and normal flowers. One of the plants, transferred to Mr. Gulick's garden, continued to produce trirostrate flowers.

In 1904 Mr. Gulick made a more careful survey of the area and found seventeen plants with all of their flowers trirostrate, two with flowers incompletely trirostrate, that is with one lateral spur quite short, and five plants with both trirostrate and normal flowers. Since then plants with all or a part of their flowers trirostrate have been found in other sections of Lorain County.

971. *Viola rafinesquii* Greene.[1]

Add Preble.

971.1. *Viola arvensis* Murr.

Add Lorain, previously reported only from Geauga.

973. *Viola odorata* L.

Add Lorain. The purple-flowered form with very long freely rooting stolons is spontaneous under hedges in Oberlin. The form with petals white, or white streaked with purple, is rather common in Oberlin lawns.

976. *Viola pallens* (Banks) Brainerd.

Add Lorain* and Trumbull.* All of the counties listed by Schaffner, except Clinton and the extreme western part of Huron, are in the eastern sandstone and shale section of the state.

977. *Viola lanceolata* L.

It has been reported from only five scattered counties. Add Lorain.*

[1]Change name to *Viola kitaibeliana* Roem. and Schultes, var. *rafinesquii* (Greene) Fernald, Rhodora 40: 443–446. Plate 526. 1938.

980. *Viola papilionacea* Pursh.

Dr. Brainerd in annotating the North American Violets in the Oberlin College Herbarium treated as true *V. papilionacea* only those specimens which were glabrous throughout. Those which were more or less pubescent he annotated "*V. papilionacea* toward *V. sororia* in subpubescence," thus treating them as probable hybrids or hybrid derivatives of the two species.

980a. *Viola papilionacea* Pursh forma *albiflora*, n. f. petalis omnino albidis, vel petalo infimo purpureo-striato.

Petals wholly white or with the lowest one streaked with purple.—Lorain, (Ob. Coll. Herb. 88410), Cuyahoga (Ob. Coll. Herb. 80002). This should be looked for elsewhere in the state.

981. *Viola sororia* Willd.

Prof. Schaffner lists eight counties, all but Wood and Lake being in the southern half of the state. To the northern group add Lorain,* Erie, Richland.*

982. *Viola hirsutula* Brainerd.

Add Licking*. This Southern Wood Violet has been reported from only four counties, all in the central part of the state, on the edge of the Appalachian plateau.

989b. *Viola pedata* L. var. *linearíloba* DC. (*V. pedata* Curtis, *V. pedata* L. var. *concolor* Theo. Holm.).

This is in the Oberlin Herbarium from Lake* and Lorain* Counties, annotated by Dr. Brainerd "*Viola pedata* L. var. *concolor* Holm." The specimen of *V. pedata* in the State Herbarium collected by Miss Alice Griswold in open woods near Painesville, Lake County, May, 1884, is this variety. Mr. Floyd Bartley recently told the writer that he had found it in the Oak Openings of Lucas County, and in Lawrence and Scioto Counties. It is probably to be found wherever the species occurs.

—. *Viola incognita* Brainerd.

Dr. Brainerd has referred two plants from Ashtabula* and Trumbull* Counties to this species. It has not previously been reported from Ohio.

988. *Viola sagittata* Ait.

987. *Viola fimbriatula* J. E. Smith (*V. ovata* Nutt.).

986. *Viola emarginata* (Nutt.) Le Conte.
Viola sagittata var. *subsagittata* Farwell.
Viola subsagittata Greene.

So much confusion exists concerning these five forms that it seems necessary to discuss them together and in some detail.

988. *Viola sagittata* Ait.

This was described from plants sent to England in 1775 from "Pennsylvania," probably by John Bartram, who about 1730 established a Botanic Garden on the bank of the Schuylkill River just below Phila-

delphia. Thus the habitat of the plants on which the species was based was probably low, moist ground of the Atlantic Coastal plain.

Aiton described the leaves as "subpubescent." Nuttall (1818) described them as "nearly smooth, or sometimes slightly pubescent on the upper side."

Later botanists have very generally considered typical *V. sagittata* to be the glabrous or nearly glabrous plant with mature leaves oblong-lanceolate, sagittately or hastately incised at base and with long peduncles. Habitat: "low grounds," "wet meadows and marshes," "moist banks and turfy meadows," in the Coastal plain from New England southward.

This interpretation of *V. sagittata* is well expressed by H. D. House, N. Y. State Mus. Bull. 243–244: 26 (1921) 1923, who in citing a plant of *V. sagittata* from near the Catskills said: "It is to be noted that this collection is the typical glabrous, slender form such as is found in the turfy meadows adjacent to the salt marshes of Long Island and southward."

It is probable that typical *V. sagittata* Ait does not occur in Ohio. The specimens in the State Herbarium and in the Oberlin College Herbarium, that have been examined, are more or less pubescent throughout, and should probably be designated *V. sagittata* Ait. var. *subsagittata* Farwell.

987. *V. fimbriatula* J. E. Smith (*V. ovata* Nutt.).

This has leaves equally pubescent on both sides, ovate to ovate-oblong, rather acute, crenate, often lacerately toothed at the base; flowers a "paler purple" or "brignt blue" instead of the deep blue of *V. sagittata*. Habitat: barren soils, sandy fields and dry hillsides. This has been reported from nine counties in Ohio, all of them except Washington being in the northern part of the state. To these add Lorain.

986. *Viola emarginata* (Nutt.) Le Conte.

This, like typical *V. sagittata*, has leaves glabrous or slightly pubescent above, but differs in having the leaves almost triangular, the base being truncate or slightly cordate; peduncles longer than the leaves; petals deep violet-blue, frequently emarginate or bidentate.

To this Dr. Greene, Pittonia 3: 255–256, 1897, adds: "True *V. emarginata* differs from *V. sagittata* not only in the broad deltoid outline of its foliage, but also in a pronounced succulency. Specimens of *V. sagittata* under good treatment dry perfectly after three or four days, while those of *V. emarginata* require seven or eight days for drying."

The habitat and distribution of *V. emarginata* according to Britton's Manual are "fields and hillsides, New York to Virginia;" according to Gray's Manual, 7th Ed., "dry woods and hillsides, New Jersey and southward," while Dr. Greene, Pittonia 3: 313, 1898, gives the distribution "in fairly typical condition" as from New York City "southward and southwestward to Louisiana and Eastern Texas."

This succulent plant with broad, deltoid, glabrous leaves seems thus to have much the same distribution as typical *V. sagittata*, and to be limited to the Atlantic and Gulf Coastal Plain. The question naturally arises as to the status of plants from Ohio and Michigan, which have been determined as *V. emarginata*.

O. A. Farwell, Papers Mich. Acad. Sci. 2: 32 (1922) 1923, discusses several plants collected by him near Detroit, one of which at least was seen by Dr. Greene and referred to *V. emarginata*. Farwell says, "Our plants are found in sandy soils, sometimes with no other vegetation, sometimes with a sparse growth of sedge grass. They are never entirely free from pubescence and never show the broad deltoid leaf characteristic of this species, but Dr. Greene said that they were nevertheless unmistakably this species."

Dr. Greene, Pittonia, 3: 313, 1898, referring to the first of the above plants which Farwell had previously labelled "*V. ovata*," said, "The leaves are all either exactly cordate-ovate or subsagittate-oblong; but in spite of this new leaf-cut, the plant is unmistakably *V. emarginata*." In view of their morphological characters, Farwell's treatment of his plants as forms of *V. ovata*, i. e., of *V. fimbriatula*, seems to be more nearly correct, especially since Nuttall himself described *V. ovata* as having "ovate, subcordate" leaves.

A plant from Lorain County in the Oberlin Herbarium, doubtfully referred to *V. emarginata* by Dr. Brainerd, conforms well to the description of Farwell's plants, and is here considered a form of *V. fimbriatula*.

The two plants in the State Herbarium, labelled *V. emarginata*, from Lake and Cuyahoga counties are loosely villous, with peduncles of the petaliferous flowers much shorter than the triangular-ovate leaves; capsules purple. They appear to be forms of *V. fimbriatula*, or segregates of *V. fimbriatula* X *sororia*.

—. *Viola sagittata* var. *subsagittata* Farwell, Papers Mich. Acad. Sci. 2: 32 (1922) 1923.

This variety, according to Farwell, has the "arrow-shaped leaves" of *V. sagittata*, but is larger and pubescent, and is found in sandy fields. His variety is based, however, on *V. subsagittata* Greene, Pittonia 3: 315, 1898.

—. *V. subsagittata* Greene.

This is described by Greene as "low, the very short-petioled leaves depressed or ascending; the whole plant at time of petaliferous flowering often only two inches high, more or less sparsely hirsute-pubescent, the sepals ciliate; vernal leaves rather narrowly cordate-ovate and small, three-fourths to one and one-fourth inches long, basal lobes almost closing the sinus; corolla very large, deep violet, often one inch long and ten or eleven lines wide, all petals white at base, the lower three densely white hairy at base, the hairs not clavellate." "Common in southern Wisconsin in rather low pasture and meadowlands, quite after the behavior of true *V. sagittata* at the East and South. By the side of true *V. sagittata* this western species appears quite dwarfed in all except its corolla, this being about twice as large as that of *V. sagittata*. But the plant has the pubescence of *V. ovata*. True *V. sagittata* seems to reach Central Illinois, and even the southern peninsula of Michigan; but I have not seen it from Wisconsin, nor *V. subsagittata* from any point to the southward or eastward of Wisconsin."

In spite of the fullness and clarity of this statement, Robinson and Fernald, Gray's Manual, 7th ed., p. 583, commenting on the distribution of *V. sagittata,* say: "In Ohio and westward a pubescent form of the species is prevalent (*V. subsagittata* Greene)."

Just what should be the taxonomic and nomenclatorial treatment of the so-called "pubescent form of *V. sagittata,*" which occurs on dry, open soils in Ohio and elsewhere has not yet been satisfactorily determined. For the present it seems best to refer these plants to *V. sagittata* Ait. var. *subsagittata* Farwell—*V. sagittata* Pursh.—not *subsagittata* Greene.

The following nine hybrids represented by herbarium specimens are known from Ohio. Only four of them have been previously reported from the state.

982 x 980. *X cordifolia* (Nutt.) Schw., Am. Jour. Sci. 5: 62, 1822, as a species; H. D. House, N. Y. State Mus. Bull. 254: 504, 1924, as a hybrid.

—*V. hirsutula X papilionacea* Brainerd, Rhodora 9: 98, 211–216, 1907. Hamilton* (Herb. E. Lucy Braun, Am. Midl. Nat. 15: 54, 1924); also Herb. Ezra Brainerd "from Ohio" (Vt. Agr. Expt. Sta. Bull. 239: 12, 1924). Add Lorain.*

Wherever these two species occur together a population of hybrids and hybrid derivatives may be expected, which will show segregation and recombination of all the characters of the two parents.

For use of students of the Ohio Violets Brainerd's table (Rhodora 9: 211) of the differing characters is given here:

		V. Hirsutula	*V. papilionacea*
Habit		Nearly prostrate	Erect
Leaves	Width	2–4 cm	5–10 cm.
	Upper surface	Hirsutulous	Glabrous
	Petioles	Glabrous	Somewhat hairy
Flowers	Color	Reddish purple	Deep violet
	Spurred petal	Villous	Glabrous
Capsules	Length	6–8 mm	10–15 mm.
	Color	Purple	Green
	Number of seeds	20–30	50–70
Seeds	Length	1.6 mm.	2 mm.
	Color	Buff	Dark brown

Dr. Brainerd has shown that purple capsules and brown seeds are dominant over green capsules and buff seeds, and that the F hybrid is intermediate between the two parents in size of capsules and of seeds.

984 x 980. *X viola modica* House, N. Y. State Mus. Bull. 254: 500, 1924.

—*Viola palmata X papilionacea* Brainerd in herb.; Dowell, Bull. Torr. Bot. Club 37: 177, 1910; Brainerd, Bull. Torr. Club 39: 85–88, pls. 5–6, 1912; Brainerd, Vt. Agr. Expt. Sta. Bull. 239: 153–155, pls. 64a, 64b, 1924.

Dowell (l. c.) says: "This differs from *V. palmata* in the direction of *V. papilionacea* by the more entire leaves, its scant pubescence, smaller

flowers on shorter peduncles, while it resembles *V. palmata* in having irregular shallow lobes on the leaves, veins prominent, and being more or less pubescent."

Brainerd (l. c.) says: "Leaves cordate-ovate as in *V. papilionacea*, lobed after the manner of *V. palmata*, but less deeply so; the capsules from cleistogamous flowers ovoid-conical, 5–7 mm. long, or half as long as the normal capsule in either parent, containing in the 48 capsules examined an average of 4½ seeds to the capsule." Lorain* (four sheets of this hybrid and its derivatives).

In the three following hybrids, *V. palmata X sagittata* Brainerd, *V. sagittata X sororia* Brainerd, and *V. sagittata X triloba* Brainerd, the *sagittata* parent is the pubescent plant of dry open fields, and gravelly soils, i. e., the *V. sagittata* var. *subsagittata* of Farwell. However, it has seemed best to maintain Brainerd's terminology, until more careful studies have clarified the status and relations of *V. sagittata* Ait., *V. subsagittata* Greene and *V. sagittata* var. *subsagittata* Farwell.

984 x 988. *X viola mistura* House. N. Y. State Mus. Bull. 254: 500, 1924.

—*V. palmata X sagittata* Brainerd, Rhodora 15: 115, 1913; Vt. Agr. Expt. Sta. Bull. 239: 157, pl. 65, 1924.

House's diagnosis (l. c.): "Leaves ciliate and more or less pubescent, subcordate, with 6–8 acute slender lobes chiefly toward the base; capsules infertile."

Lorain* and Erie (three sheets of this hybrid or its segregates).

988 x 981. *Viola sagittata X sororia* Brainerd, Vt. Agr. Expt. Sta. Bull. 239: 193, pl. 78, 1924.

"Plants varying in leaf-outline from ovate with crenate-serrate margin, as in *V. sororia*, to lanceolate with hastate basal lobes, as in *V. sagittata*; varying also in like manner as respects other characters that differentiate the parent species."

Erie, collected with its putative parents in dry, gravelly soil, top of bluff near Birmingham.

988 x 983. *X viola caesariensis* House, N. Y. State Mus. Bull. 254: 506, 1924.

—*V. sagittata X triloba* Brainerd. Rhodora 15: 115, 1913; Vt. Agr. Expt. Sta. Bull. 239: 195, pl. 79, 1924; first described, Rhodora 8: 54, 1906, as *V. palmata X sagittata* Brainerd.

"Differing from *V. sagittata* in having wider pubescent leaf-blades more or less lobed near the middle, in having cleistogamous flowers with appressed ciliate auricles, and in having a brown-spotted summer capsule on much shorter peduncles; differing from *V. triloba* in having ovate-oblong leaves with coarsely toothed or incised basal lobes, and in having long slender cleistogamous flowers on ascending peduncles; in each case the difference being in the direction of qualities possessed by the other parent."

Lorain* (a single plant annotated by Dr. Brainerd, as apparently a segregate from this hybrid).

984 x 981. *X Viola peckiana* House, N. Y. State Mus. Bull. 254: 500, 1924.

= *V. palmata X sororia* House, N. Y. State Mus. Bull. 243–244: 53 (1921) 1923; idem 254: 500, 1924.

House's diagnosis (l. c.): "Early leaves broadly ovate to reniform, entire or with some of the leaves slightly lobed, somewhat pubescent above, glabrous beneath and on the petioles; later leaves softly and rather densely pubescent on the petioles and lower leaf surfaces, the blades less pubescent above, variously 3-7-lobed or nearly entire; flowers abundant, but soon withering without developing fruit; capsules all from cleistogamous flowers on short, horizontal, or deflexed and buried peduncles. Growing with *V. palmata* and *V. sororia*."

Brainerd, Vt. Agr. Expt. Sta. Bull. 239: 159, pl. 66, 1924, in discussing this hybrid, said: "About ten years ago I received from Miss E. Lucy Braun of Cincinnati, Ohio, specimens of an anomalous violet in flower, collected in 'dry woods, Hamilton County.' With this was sent a drawing of its mature leaves and fruit. The foliage in outline and pubescence is quite the same as in the hybrid here discussed." Hamilton* (herb. E. Brainerd, l. c., p. 13). Add Lorain.

980 x 981. *X Viola napae* House, N. Y. State Mus. Bull. 254: 501, 1924.

= *V. papilionacea X sororia* Brainerd in herb.; Dowell, Bull. Torr. Bot. Club 37:178, 1910.

Dr. Dowell says: "This differs from *V. sororia* in having longer petioles, thinner leaves, and less pubescence, while it differs from *V. papilionacea* in being decidedly more or less pubescent."

Hamilton* (herb. Ezra Brainerd, Vt. Agr. Expt. Sta. Bull. 239:169, 1921; herb. E. Lucy Braun, Am. Midl. Nat. 15: 54, 1934). Add Lorain.*

970 x 967. *X Viola braunii* nom. nov.

= *V. rostrata X striata* Brainerd, Vt. Agr. Expt. Sta. Bull. 239: 191, pl. 77, 1924.

Brainerd's diagnosis: "Outline of leaf-blade broadly ovate-cordate, acuminate; stipules slightly fimbriate as in *V. rostrata*; like *V. striata* in its thick, short, blunt spur and bearded lateral petals."

Dr. Brainerd described this hybrid from specimens collected by Miss E. Lucy Braun, May 27, 1917, and May 26, 1918, near Terrace Park, Hamilton* Co., Ohio. At the same time she collected both parent species. Two sheets of this hybrid from Miss Braun's collections are in the Ezra Brainerd herbarium, (l. c., p. 14), and others in the herbarium of Miss Braun (Am. Midl. Nat. 15:54. 1934).

981 x 983. *X Viola populifolia* Greene, as a species, Pittonia 3: 337, 1898; House, N. Y. State Mus. Bull. 254: 502, 1924.

= *V. sororia X triloba* Brainerd, Torr. Bot. Club. Bull. 39: 92–93, 1912; Vt. Agr. Expt. Sta. Bull. 239: 199, pl. 8, 1924.

Greene (l. c.) says of *V. populifolia*: "An acaulescent blue-flowered woodland violet akin to *V. cuspidata* Greene [= *V. sororia*, according

to Brainerd], but smaller, petioles of the early leaves densely villous-hirsute, the blade from broad cordate in the very earliest and smallest, to deltoid or deltoid-reniform in those accompanying the petaliferous flowers, notably broader than long, both surfaces, but more conspicuously the lower, hirsute-pubescent, especially along the veins; . . ."

Brainerd (l. c.) says: "The shallow and obscure lobes of the hybrid are the same as in *V. papilionacea X triloba*, but the foliage is never glabrous." . . . "The leaf outline in *V. triloba* is relatively broader and less deeply cordate than in *V. sororia* (or in *V. papilionacea*), and the hybrid offspring may inherit the uncut leaves of the latter and the broad outline of the former, thus presenting a decidedly reniform leaf." Lorain.* (Three sheets.)

New Versions of Well-Known Textbooks of Plant Physiology

The second edition of Miller's "Plant Physiology" is an enlargement and revision of the first edition which appeared in 1931. The general plan of the earlier edition has been retained. The increased size of the book is due chiefly to inclusion of the results of recent investigations. The bibliographies, a valuable feature of this book, are even more comprehensive in the present than in the earlier edition. This volume will undoubtedly continue to be the most useful modern reference textbook for advanced students, teachers, and investigators, but because of its length and encyclopedic presentation of subject matter is not well adapted for general classroom use.

"Plant Physiology," the English version of the Fifth Russian Edition of Maximov's textbook differs considerably from the earlier "A Textbook of Plant Physiology" (1930) which was based on the Second Edition of the Russian textbook. The current edition is not only more comprehensive than the earlier one but an entirely different and distinctive organization has been followed. The physico-chemical organization of the plant and its chemical compositions are first discussed, followed by chapters on respiration and growth. Next come five chapters dealing with fundamental plant processes. The last five chapters deal, in order, with the resistance of plants to unfavorable environmental conditions, correlations and vegetation propagation, physiology of development, physiology of reproduction, and seasonal phenomena in the life of plants. The author's intention is "to reproduce for the student as clearly as possible a complete picture of the life of the plant, not as a sum of separate physiological functions, but as a unified developing process beginning with the germination of seeds and terminating with the maturing of seeds newly reproduced by the plant." The reviewer is more in sympathy with the author's avowed purpose than he is with the organization which has been adopted in attempting to achieve that objective. Instead of leading the student on, step by step, and with ever-widening capacity for the interpretation of increasingly complex phenomena, the transition from subject to subject is often abrupt and psychologically illogical, so that the chapters must certainly appear as a series of only loosely related topics to the uninitiated student. The book does contain much sound and interesting information, and is quite worthwhile from this standpoint. The number of uncritical or misleading statements is greater, however, than should be tolerated in any introductory textbook.—*B. S. Meyer.*

Plant Physiology, 2nd Ed., by E. C. Miller. 1201 pp. New York, The McGraw-Hill book Co., 1938. $7.50.

Plant Physiology, by N. A. Maximov, edited by R. B. Harvey and A. E. Murneek. 473 pp. New York, The McGraw-Hill Book Co., 1938. $4.50.

ARGIA FUMIPENNIS IN OHIO

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The writer was quite surprised on the morning of January 31, 1939—with some snow still on the ground—to have presented to him a live male of *Argia fumipennis* Burmeister. Upon investigation it was discovered that this specimen was obtained from the Botany Greenhouse on the Ohio State University Campus in Columbus, Ohio. Two days later the nymphal exuvium was found clinging to the side of one of the glass aquaria.

Dr. G. W. Blaydes of the Botany Department of O. S. U. very kindly investigated the source from which the plants in these aquaria were obtained and found that they had been purchased from a firm in Tampa, Florida.

The literature shows that this species has been taken as far north as Kentucky (H. Garman, 1924). P. Garman (1917) states, "This species [*Argia fumipennis*] has not been reported from Illinois but has been reported from Kentucky, and may possibly be taken in southern Illinois." Borror (1937) does not list this species from Ohio.

The writer has captured numbers of *Argia fumipennis* in shaded woodland areas near running water at various localities in the Central Gulf Coast Region. This species seems to be rather distinctly a southern form. Its capture in central Ohio, even though bred in a greenhouse, is of interest as it shows one possible way in which the range of such an insect might be extended. If the environmental conditions were favorable, adults of a species which had been artificially transported, in the nymphal stage, to a region beyond its known range might there escape from the sheltered place, in which it had emerged, and oviposit in some suitable aquatic habitat. Then, if there were sufficient vegetation and depth of water present to prevent freezing of the immatures, it is quite probable that the species would become established in that region.

In addition, on March 13, 1939, a male of *Ischnura posita* Hagen and a female of *Ischnura verticalis* Say were taken in a different room in the Botany Greenhouse. Both of these species, however, are common inhabitants of Ohio.

LITERATURE CITED

Borror, D. J. 1937. An Annotated List of the Dragonflies of Ohio. Ohio Jour. Sci. 37 (3): 185–196.
Garman, H. 1924. Odonata from Kentucky. Ent. News. 35: 285–288.
Garman, P. 1917. Zygoptera, or Damsel Flies, of Illinois. Bull. Ill. State Lab. Nat. History 12, article 4.

Physical Meteorology

As the title indicates, in the book under review consideration is devoted primarily to the various physical aspects of meteorology and to the operation of those physical laws and principles producing or explaining the phenomena grouped under the general term "weather." In so far as such a treatment of the subject matter was the goal of the author he has been successful but, as will be evident from examples cited below, less success attended his efforts to provide mathematical justification for certain of the formulas and results appearing in the text.

In addition to a well written discussion of the standard subject matter of meteorology, the book contains particularly good popular accounts of the dynamics of motions in the atmosphere and of the theory and classification of extratropical cyclones. Here the author has written with an interest and enthusiasm which can scarcely fail to be shared by the reader; although the latter may deprecate the use of the outmoded law of Stokes rather than the corrected form of this law due to Cunningham and Millikan in the treatment of the settling of dust through the air, or the appearance of the statement made on page 194 in regard to the condition for convection to be initiated.

In this book, as in all modern physical texts, the importance of mathematical formulation of physical situations is clearly recognized and, as a result, the book cannot be read in its entirety without an understanding of at least the elements of differential and integral calculus. However, the mathematical portions of the text, are, to a considerable extent, additions to an otherwise complete treatment and, as such mathematical addenda are almost always printed in fine type, it is possible for the non-mathematical reader to avoid embarrassment. The device of printing mathematical discussions in small type has the further advantage of setting off those sections which appear to have been prepared with less care than the remainder of the book. For example, in the discussion of the escape of planetary atmospheres (page 14) the correct formula for the work done in removing a particle from the surface of a planet to infinity is obtained only by a fortunate combination of errors. In this connection, it seems worth while to note, on the one hand, that the recent papers of E. A. Milne and J. E. Jones have shown that the problem of escape of atmospheres is far too delicate to be solved by the argument presented in the text and, on the other hand, that there are excellent reasons for doubting the moon to be "quite devoid of any atmosphere."—*L. LaPaz.*

Physical Meteorology, by John G. Albright. xxvii+392 pp. New York, Prentice-Hall, Inc., 1938. $5.35.

PROTOZOAN PARASITES OF THE ORTHOPTERA, WITH SPECIAL REFERENCE TO THOSE OF OHIO

II. Description† of the Protozoan Parasites Recognized in This Study.‡

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Mastigophora

Leptomonas sp. (Plate I, Figs. 1 and 2.)

Hosts: *Parcoblatta virginica* (Brunner); *P. lata* (Brunner); *P. pen(n)sylvanica* (DeGeer).

Habitat: Hind-intestine.

Distribution: Champaign, Fairfield, Franklin, Hocking, Logan, Madison, and Washington Counties, Ohio.

Description: The organism is asymmetrically pyriform, 7.5 to 9μ in length by 3 to 4.5μ in width. The nucleus is granule-like. There is a single flagellum, 12 to 15μ in length and the blepharoplast is indistinguishable from the base of the flagellum. Leishmania-like organisms are present which are ovoid in shape and approximately 5 by 4μ in size, and possess two minute granule-like bodies (apparently nucleus and blepharoplast) and a short filament.

Affinities: By description (there is no illustration) this organism resembles *Leptomonas blaberae* Tejera, 1926, differing as to host (*Blabera* sp., Venezuela), length of flagellum (15 to 25μ), and slightly as to size (6.8 to 8 by 2.5 to 6μ).

Comment: It is inadvisable, because of insufficient characterization, to name this organism at the present.

Sporozoa

Leidyana gryllorum (Cuénot, 1897) Watson, 1916. (Plate I, Fig. 3.)

References: Cuénot, 1897a, 54; Labbé, 1899, 10; Cuénot, 1901, 594; Watson, 1916a, 120; Bhatia and Setna, 1924, 288.

Synonymy: *Clepsidrina gryllorum* Cuénot, 1897a, 54; *Gregarina macrocephala* Labbé, 1899, 10; *G. gryllorum* Cuénot, 1901, 594; *Leidyana gryllorum* Watson, 1916a, 120.

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†All descriptions are made from types and paratypes on slide mounts in the author's collection.

‡Contributions from the Department of Zoology and Entomology, Number 112, Part II.

Hosts: *Gryllus assimilis* Fabricius; **G. domesticus* (Linnaeus); **G.* spp.; **Nemobius sylvestris* (Bosc d'Antic); *N. fasciatus fasciatus* (DeGeer).

Habitat: *Alimentary canal; *gizzard; enteric ceca; **mid-intestine.

Distribution: *Ardennes, Nancy, Joinville, and Roscoff, France; *Lahore, India; Franklin and Washington Counties, Ohio.

Description: The protomerite of this organism is a sphere, flattened posteriorly; the deutomerite is cylindric to tapering, terminating in a blunt point. There is a marked constriction at the septum. The epicyte and sarcocyte, collectively, are extremely thin over the entire surface. The endoplasm of the protomerite is moderately opaque and is white in reflected light; that of the deutomerite is somewhat more opaque in transmitted light. The nucleus is spherical and contains no karyosomes.

The measurements of the organism are as follows: Length and width of protomerite, 45 to 59μ by 65 to 71μ, averaging 52 by 68μ; of the deutomerite, 150 to 230μ by 78 to 97μ, averaging 190 by 87.5μ. Total length of the organism is 195 to 289μ, averaging 242μ. The nucleus is 32 to 39μ in diameter, averaging 35.5μ. (For all of the Gregarinida, measurements were taken of the representative specimens.)

Proportions are as follows: Length of protomerite to total length varies from 1 : 4.3 to 1 : 4.9, averaging 1 : 4.6; width of protomerite to width of deutomerite varies from 1 : 1.2 to 1 : 1.4, averaging 1 : 1.3.

No movement was observed, the organism usually being attached to debris posteriorly.

Two cephalonts (with globular epimerites) were observed. No other stages were recognized.

Comment: Approximately five stages intermediate between *Leidyana gryllorum* (Cuénot) and *L. erratica* (Crawley) were observed, indicating that these species might be extreme types of the same species. This corroborates the observations of Bhatia and Setna (1924, 288), who doubted that these Leidyanas were distinct species. A more complete statement will be withheld until further work has been done in this direction.

Leidyana erratica (Crawley, 1907) Watson, 1915. (Plate I, Figs. 4, 5, 6.)

References: Crawley, 1903a, 45; Crawley, 1903b, 639, 641; Crawley, 1907, 221; Ellis, 1913c, 286; Watson, 1915, 35; Watson, 1916a, 118; Kamm, 1922a, 133; Bhatia and Setna, 1924, 288.

Synonymy: *Gregarina achetaeabbreviatae* Crawley, 1903a, 45; *Stephanophora erratica* Crawley, 1907, 221; *Leidyana solitaria* Watson, 1915, 35; *L. erratica* Watson, 1916a, 118.

Hosts: ***Gryllus assimilis* Fabricius; **G.* spp.; *Nemobius fasciatus fasciatus* (DeGeer); *N. fasciatus socius* Scudder; *Anaxipha exigua* (Say); *Hapithus agitator agitator* Uhler.

Habitat: *Alimentary canal; *gizzard; **enteric ceca; **mid-intestine.

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*Of other investigators only.

**Of the author as well as of other investigators

Unstarred information is of the author only.

Distribution: *Lahore, India; *Urbana, Illinois; *Cold Spring Harbor and Oyster Bay, New York; Champaign, Franklin and Washington Counties, Ohio.

Description: The protomerite of this organism is diamond-shaped; the deutomerite is cylindric and broadly rounded posteriorly, or tapering, terminating in a point, which varies from blunt to sharp. There is little or no constriction at the septum. The epicyte and sarcocyte, collectively, are extremely thin over the entire surface. The endoplasm of the protomerite is moderately opaque, and is white to yellowish in reflected light; that of the deutomerite is somewhat more opaque. The nucleus is spherical and contains no karyosomes.

The measurements are as follows: Length and width of protomerite, 22 to 91μ by 32 to 82μ, averaging 49.5 by 57μ; of the deutomerite, 195 to 435μ by 50 to 130μ, averaging 303 by 97μ. Total length of the organism, 217 to 526μ, averaging 352.5μ. Diameter of the nucleus, 15 to 58μ, averaging 35μ.

The proportions are as follows: Length of protomerite to total length varies from 1 : 5.8 to 1 : 9.6, averaging 1 : 7.3; width of protomerite to width of deutomerite varies from 1 : 1.2 to 1 : 2.2, averaging 1 : 1.7.

No movement was observed, the organism being almost invariably attached posteriorly to debris.

No other stages in the life cycle of the organism were recognized.

Comment: See comment for *Leidyana gryllorum.*

Gregarina ohioensis n. sp. (Plate I, Fig. 7.)

Hosts: *Parcoblatta virginica* (Brunner).

Habitat: Mid-intestine.

Distribution: Franklin County, Ohio.

Description: The primite protomerite of this organism is dome-like, and the deutomerite, an elongate cylinder. The satellite protomerite is flattened, and the deutomerite, elongate, tapering posteriorly to a point. There is no constriction at the septum of the primite, little at that of the satellite. The epicyte and sarcocyte of the association, collectively, are 19μ and less in thickness in the protomerites and 10μ, becoming much thinner posteriorly, in the deutomerites. The endoplasm of the association is moderately opaque, and is white in reflected light. The nucleus in both primite and satellite is a sphere, somewhat compressed.

The measurements are as follows: Length and width of primite protomerite, 123 by 247μ; of primite deutomerite, 910 by 292μ; of satellite protomerite, 110 by 286μ; of satellite deutomerite, 1072 by 292μ. Total length of primite, 1033μ; of satellite, 1182μ. Total length of association, 2215μ. Diameter of nuclei of primite and satellite, 65μ.

The proportions are as follows: Length of primite protomerite to total length, 1 : 8.4; of satellite, 1 : 10.7. Width of primite protomerite to width of deutomerite, 1 : 1.2; of satellite, 1 : 1.0.

No movement was observed.

*Of other investigators only.

No other stages were recognized.

Affinities: This organism resembles a variety of *Gregarina blattarum* Siebold, 1839, perhaps a distinct species, described by M. E. Watson (1916b), differing from it as follows: The primite protomerite of *G. ohioensis* n. sp. is dome-like and there is no constriction of the primite; the primite protomerite of Watson's variety of *G. blattarum* S. is bluntly pointed and there is a perceptible constriction of the primite.

The organism also resembles *Gregarina illinensis* Watson, 1915, differing from it as follows: The posterior end of the satellite is pointed in *G. ohioensis* n. sp. and rounded in *G. illinensis* W. There is no primite constriction in *G. ohioensis*, a perceptible one in *G. illinensis*. Other lesser differences may be noted.

Gregarina thomasi§ n. sp. (Plate I, Fig. 8.)

Hosts: *Parcoblatta pensylvanica* (DeGeer).

Habitat: Enteric ceca; mid-intestine.

Distribution: Fairfield County, Ohio.

Description: The primite protomerite of the organism is an elongate, blunt cone, irregularly shaped, and the deutomerite is elongate and irregular, slightly tapering posteriorly. The satellite protomerite is flattened, and the deutomerite is elongate and irregular, tapering to a blunt point. There is no constriction at the septa. The epicyte and sarcocyte of the association are 15μ and less in thickness in the protomerites, and are extremely thin in the deutomerites. The endoplasm of the association is translucent, and is white in reflected light. The nuclei are spherical and contain no karyosomes.

The measurements are as follows: Length and width of primite protomerite, 162 to 195μ by 182 to 195μ, averaging 170 by 187μ; of primite deutomerite, 710 to 910μ by 215 to 260μ, averaging 811 by 237μ; of satellite protomerite, 71 to 97μ by 195 to 218μ, averaging 79 by 207μ; of satellite deutomerite, 747 to 845μ by 227 to 295μ, averaging 792 by 268μ. Total length of primite, 872 to 1105μ, averaging 981μ; of satellite, 818 to 1592μ, averaging 871μ. Total length of association 1690 to 2697μ, averaging 1852μ. Diameter of nuclei of primite and satellite, 65μ each.

The proportions are as follows: Length of primite protomerite to total length varies from 1 : 4.6 to 1 : 6.6, averaging 1 : 5.65; of satellite, 1 : 10 to 1 : 12.7, averaging 1 : 11.35. Width of primite protomerite to width of deutomerite varies from 1 : 1.1 to 1 : 1.4, averaging 1 : 1.25; of satellite, 1 : 1.2 to 1 : 1.4, averaging 1 : 1.3.

The movement is slow, with twisting about debris in the path of the organism.

No other stages were recognized.

Affinities: This organism resembles *G. ohioensis* n. sp., differing from it as follows: The primite protomerite of *G. thomasi* n. sp. is an elongate, irregular, blunt cone; that of *G. ohioensis* n. sp. is dome-like. The primite deutomerite of *G. thomasi* n. sp. is irregular in shape and tapers slightly posteriorly; that of *G. ohioensis* n. sp. is regularly

§In honor of Edward S. Thomas, Curator of Natural History, Ohio Museum.

cylindrical. There is no constriction of the satellite in *G. thomasi* n. sp. while that in *G. ohioensis* is perceptible.

The organism differs from *G. blattarum* Siebold, Watson variety, in shape of primite protomerite, which is an elongate, irregular, blunt cone in *G. thomasi*, and is a papillate cone of moderate length in *G. blattarum*. There is a perceptible constriction of both primite and satellite in *G. blattarum*, none in *G. thomasi*.

The same differences are found when *G. thomasi* is compared with *G. illinensis* Watson, which has a primite protomerite which is broadly rounded and almost spherical, and which has perceptible constrictions of both primite and satellite. A number of lesser differences may be noted.

Gregarina parcoblattae n. sp. (Plate I, Figs. 9, 10, and 11.)

Hosts: *Parcoblatta uhleriana* (Saussure); *P. pensylvanica* (DeGeer).

Habitat: Mid-intestine.

Distribution: Fairfield and Washington Counties, Ohio.

Description: The primite protomerite of the organism is flattened and regularly or irregularly rounded; the deutomerite is cylindric. The satellite protomerite is flattened, and the deutomerite is cylindric. There is a marked constriction at the septum of both primite and satellite. The epicyte and sarcocyte of the association are apparently extremely thin. The endoplasm of the association is very opaque, and is white in reflected light. The nuclei are spherical and contain no karyosomes.

The measurements are as follows: Length and width of primite protomerite, 90 to 130μ, by 143 to 208μ, averaging 112 by 174μ; of primite deutomerite, 390 to 553μ by 215 to 325μ, averaging 474 by 267μ; of satellite protomerite, 59 to 97μ by 112 to 260μ, averaging 78.5 by 185.5μ; of satellite deutomerite, 443 to 650μ by 214 to 390μ, averaging 549.5 by 289μ. Total length of primite, 480 to 683μ, averaging 586μ. Total length of association, 982 to 1430μ, averaging 1214μ. Diameter of primite nucleus, 45 to 65μ, averaging 55; of satellite nucleus, 45 to 65μ, averaging 58μ. Nuclei were sometimes invisible because of the opacity of the cell.

The proportions are as follows: Length of primite protomerite to total length varies from 1 : 5.0 to 1 : 5.6, averaging 1 : 5.3; of satellite, 1 : 6.7 to 1 : 9.1, averaging 1 : 8.0. Width of primite protomerite to width of deutomerite varies from 1 : 1.4 to 1 : 1.8, averaging 1 : 1.6; of satellite, 1 : 1.2 to 1 : 1.8, averaging 1 : 1.5.

The movement is slow, without flexion. The organism is often attached posteriorly to debris.

Two cysts were observed. These were 290μ in diameter, or 475μ including the transparent outer layer. They were very opaque and were white in reflected light. Dehiscence was not observed. No other stages were recognized.

Affinities: This organism resembles *Gregarina blattarum* Siebold, Watson variety, differing as follows: The shape of the primite protomerite in *G. parcoblattae* n. sp. is flattened and broadly rounded, regularly or irregularly; that of *G. blattarum* is papillate. The deutomerites of *G. parcoblattae* are cylindric and square cornered; those

of *G. blattarum* are between cylindric and ovoid. Lesser differences can be seen.

Gregarina rigida columna n. subsp. (Plate I, Figs. 12 (?), 13.)

Hosts: *Arphia sulphurea* (Fabricius); *Chortophaga viridifasciata* (DeGeer); *Encoptolophus sordidus* (Burmeister); *Pardalophora apiculata* (Harris); *Dissosteira carolina* (Linnaeus); *Spharagemon bolli* Scudder; *S. collare collare* (Scudder); *Melanoplus obovatipennis* (Blatchley); *M. scudderi scudderi* (Uhler); *M. differentialis* (Thomas); *M. bivittatus* (Say); *M. mexicanus mexicanus* (Saussure); *M. keeleri luridus* (Dodge).

Habitat: Enteric ceca; mid-intestine.

Distribution: Gary, Indiana; Fairfield, Franklin, Licking, Union, and Washington Counties, Ohio.

Description: The primite protomerite of the organism is dome-like; the deutomerite is cylindric. The satellite protomerite is somewhat flattened and is often continuous with the deutomerite; the deutomerite is cylindric. There is very little or no constriction at the septum of either primite or satellite. The epicyte and sarcocyte, collectively, of the association vary from 4 to 20μ in thickness, usually being of uniform thickness throughout, but sometimes being much thicker in the primite protomerite. The endoplasm is moderately opaque and is yellow in reflected light. The nuclei are spherical and contain eight or more small karyosomes.

The measurements are as follows: Length and width of primite protomerite, 52 to 195μ by 85 to 214μ, averaging 117 by 157μ; of primite deutomerite, 165 to 780μ by 97 to 292μ, averaging 412 by 177μ; of satellite protomerite, 46 to 101μ by 85 to 219μ, averaging 60 by 141μ; of satellite deutomerite, 228 to 650μ by 85 to 210μ, averaging 384 by 147μ. Total length of primite, 217 to 975μ, averaging 529μ; of satellite, 274 to 751μ, averaging 444μ. Total length of association, 491 to 1726μ, averaging 973μ. Diameter of primite nucleus, 39 to 65μ, averaging 58μ; of satellite nucleus, 39 to 67μ, averaging 52μ.

The proportions are as follows: Length of primite protomerite to total length varies from 1 : 3.7 to 1 : 6.1, averaging 1 : 5.5; of satellite, 1 : 5.0 to 1 : 7.7, averaging 1 : 6.1. Width of primite protomerite to width of deutomerite varies from 1 : 1.0 to 1 : 1.2, averaging 1 : 1.1; of satellite, 1 : 0.9 to 1 : 1.2, averaging 1 : 1.0.

The movement is slow and deliberate, without flexion.

For other stages in the life history, see *Gregarina rigida rigida* (Hall).

Affinities: This organism closely resembles *Gregarina rigida* (Hall), given in this paper as *G. rigida rigida* (Hall), differing from it as follows: The primite protomerite of *G. r. columna* is dome-like, almost as wide as that of the deutomerite, and has little or no constriction; that of *G. r. rigida* is flattened, usually much narrower than the deutomerite, and a constriction is always present, usually marked. The ratio of the width of the deutomerite to that of the protomerite was taken as the principal diagnostic character in setting apart these two subspecies. So far as can be determined from the illustrations of other investigators (most of the written descriptions are inadequate), the ratio 1 : 1.3 may be taken as the lower limit for *G. r. rigida*, Watson (1916a, 105) giving 1 : 1.4 as that of the typical organism. The mean width ratio of all

specimens of *G. r. rigida* observed in this study was 1 : 1.5. Ten percent of these showed a ratio of 1 : 1.3; ten percent 1 : 1.4; six percent 1 : 1.5; twelve percent 1 : 1.7 and four percent 1 : 1.8. The mean width ratio of all specimens of *G. r. columna* was 1 : 1.1 with eleven percent showing 1 : 1.0; twenty-six percent 1 : 1.1 and twenty-one percent 1 : 1.2.

Aside from the mean width ratios (not conclusive in themselves), a factor that might tend to support a distinction between the two subspecies is the fact that they are seldom found in the same individual host. Also, a distinctive tendency in some of the individuals of the 1 : 1.0 to 1.2 range is a lengthening of the protomerite of the primite, the ratio approximating 1 : 1 (length to width) in three of those observed, two of them with the 1 : 1.1 width ratio, and one with the 1 : 1.2.

The intergrading individuals represent a link between the two subspecies which makes it inadvisable at the present to raise *G. r. columna* n. subsp. to the specific rank.

Gregarina rigida rigida (Hall, 1907) Ellis, 1913. (Plate I, Fig. 14.)

References: Hall, 1907, 150, 169, etc.; Crawley, 1907, 223; Sokolow, 1911, 279; Wellmer, 1911, 108; Ellis, 1913a, 464; Ellis, 1913b, 82; Ellis, 1913c, 267; Watson, 1915, 34; Watson, 1916a, 105; Kamm, 1920, 23.

Synonymy: *Hirmocystis rigida* Hall, 1907, 150, 169, etc.; *Gregarina melanopli* Crawley, 1907, 223; *Gregarina rigida* Ellis, 1913c, 267; *Gregarina rigida rigida* n. subsp.

Hosts: *Chorthippus curtipennis curtipennis* (Harris); *Arphia sulphurea* (Fabricius); **Encoptolophus sordidus* (Burmeister); *Dissosteira carolina* (Linnaeus); *Spharagemon bolli* Scudder; **Brachystola magna* (Girard); **Schistocerca americana americana* (Drury); **Hesperotettix viridis pratensis* (Scudder); *Melanoplus obovatipennis* (Blatchley); ***M. differentialis* (Thomas); ***M. bivittatus* (Say); ***M. femur-rubrum femur-rubrum* (DeGeer); ***M. mexicanus mexicanus* (Saussure); ** *M. keeleri luridus* (Dodge); **M. angustipennis* (Dodge).

Habitat: *Alimentary canal; gizzard; **enteric ceca; mid-intestine.

Distribution: *Canon City and Colorado Springs, Colorado; *Urbana, Illinois; Gary, Indiana; *Douglas Lake, Michigan; *Lincoln, Nebraska; *Oyster Bay, New York; Fairfield, Franklin, Licking, and Washington Counties, Ohio; *Wyncote, Pennsylvania.

Description: The primite protomerite of the organism is flattened and broadly rounded; the deutomerite is cylindric. The satellite protomerite is flattened and the deutomerite cylindric. There is a marked constriction at the septa. The epicyte and sarcocyte, collectively, are very thin and of even thickness throughout, except occasionally in the primite protomerite, where they may become as much as 20μ in thickness. The endoplasm of the association is moderately opaque, and is yellow in reflected light. The nuclei are spherical,

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**Of the author as well as of other investigators.

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containing 1 to 10 karyosomes, the exact number being difficult to determine because of the opacity of the nucleus.

The measurements are as follows: Length and width of primite protomerite, 52 to 130μ by 72 to 170μ, averaging 88 by 122μ; of primite deutomerite, 163 to 468μ by 124 to 280μ, averaging 288 by 177μ; of satellite protomerite, 39 to 71μ by 72 to 208μ, averaging 58 by 127μ; of satellite deutomerite, 182 to 650μ by 97 to 260μ, averaging 325 by 181μ. Total length of primite, 215 to 598μ, averaging 376μ; of satellite, 221 to 721μ, averaging 383μ. Total length of association, 436 to 1319μ, averaging 759μ. Diameter of primite nucleus, 39 to 78μ, averaging 52μ; of satellite nucleus, 33 to 78μ, averaging 53μ.

The proportions are as follows: Length of primite protomerite to total length varies from 1 : 3.7 to 1 : 5.9, averaging 1 : 4.3; of satellite, 1 : 3.9 to 1 : 11.0, averaging 1 : 6.7. Width of primite protomerite to width of deutomerite varies from 1 : 1.3 to 1 : 1.8, averaging 1 : 1.5; of satellite, 1 : 1.3 to 1 : 1.7, averaging 1 : 1.45.

No movement was observed. The organisms are usually attached posteriorly to debris.

Numerous cephalonts were observed. Each possessed a globular epimerite. Cysts, averaging 260μ in diameter, or 325μ, including the transparent outer layer, were seen. These were very opaque, and were shades of yellow in reflected light. (It was impossible to determine whether the cephalonts and cysts were of this subspecies or of *G. rigida columna* n. subsp.) Dehiscence of cysts was not observed.

Affinities: See *Gregarina rigida columna* n. subsp.

Gregarina indianensis n. sp. (Plate I, Figs. 15 and 16.)

Hosts: *Chorthippus curtipennis* (Harris); *Melanoplus differentialis* (Thomas); *M. bivittatus* (Say); *M. mexicanus mexicanus* (Saussure).

Habitat: Enteric ceca; mid-intestine.

Distribution: Gary, Indiana.

Description: The primite protomerite of the organism is cylindric to conic, and is truncated anteriorly; the anterior end is invaginated. The primite deutomerite is cylindric. The satellite protomerite approximates that of the primite in shape; the deutomerite is cylindric to tapering posteriorly, ending bluntly. There is little or no constriction at the septum of the primite; that of the satellite is slight. The epicyte and sarcocyte, collectively, are extremely thin throughout. The endoplasm of the association is moderately opaque, and is shades of yellow in reflected light. The nuclei are spherical and each possesses two large karyosomes.

The measurements are as follows: Length and width of primite protomerite, 97 to 151μ by 85 to 124μ, averaging 128 by 101μ; of primite deutomerite, 228 to 357μ by 104 to 176μ, averaging 316 by 133μ; of satellite protomerite, 65 to 97μ by 97 to 124μ, averaging 78 by 114μ; of satellite deutomerite, 221 to 338μ by 118 to 130μ, averaging 294 by 124μ. Total length of primite, 325 to 508μ, averaging 444μ; of satellite, 286 to 435μ, averaging 372μ. Total length of association, 611 to 943μ, averaging 816μ. Diameter of each nucleus, 44 to 52μ, averaging 48μ.

The proportions are as follows: Length of primite protomerite to total length varies from 1 : 3.4 to 1 : 3.8, averaging 1 : 3.5; of satellite, 1 : 4.0 to 1 : 6.2, averaging 1 : 4.85. Width of primite protomerite to width of deutomerite varies from 1 : 1.2 to 1 : 1.4, averaging 1 : 1.3; of satellite, 1 : 1.0 to 1 : 1.3, averaging 1 : 1.1.

No movement was observed. The organisms are usually attached posteriorly to debris.

Cephalonts were very numerous. Each has a cylindrical epimerite, terminating bluntly. The protomerite is wider at the anterior end than at the base, presenting every gradation from this condition to that of the adult. No additional stages in the life history were recognized.

Affinities: This organism bears a marked resemblance to *Gregarina nigra* Watson, 1915 and possibly there is a close relationship between them. The differences are as follows: The primite protomerite of *G. nigra* has a minute indentation at the apex; that of *G. indianensis* has the anterior end depressed. The epicyte is thickened at the anterior end of the protomerite in *G. nigra*, very thin throughout in *G. indianensis*. The nucleus of *G. nigra* contains many karyosomes and is not visible in vivo; that of *G. indianensis* contains two (rarely three) karyosomes and is visible in vivo. The endoplasm of *G. nigra* is more opaque than that of *G. indianensis*.

It is interesting to add here that Bush (1928, 153) describes a *Legeria* sp. from Natal (U. S. Africa) that very closely resembles the immature sporonts of *G. indianensis*. Also he describes an organism which he identifies as *G. nigra* which might be a close relative of *G. indianensis*. It would follow, then, that *Legeria* sp. Bush, 1928 might be the immature sporont of *G. nigra*, Natal variety. Apparently neither Watson nor Bush recognized the immature sporonts of *G. nigra*.

Gregarina nigra Watson, 1915. (Plate I, Fig. 17.)

References: Watson, 1915, 33; Watson, 1916a, 116; Kamm, 1922a, 130; Kamm, 1922b, 84; Bush, 1928, 154 et al.

Synonymy: Name unchanged.

Hosts: **Encoptolophus sordidus* (Burmeister); *Zonocerus elegans* (Thunberg); **Lentula* sp.; **Cyrtacanthacris ruficornis* (Fabricius); **Melanoplus differentialis* (Thomas); ***M. femur-rubrum femur-rubrum* (DeGeer).

Habitat: *Alimentary canal; mid-intestine.

Distribution: *Pietermaritzburg, Natal; *Urbana, Illinois; Washington County, Ohio.

Description: The primite protomerite of the organism is conic, with a small pit at the apex; the deutomerite is cylindric except at the extreme posterior end, where it becomes swollen. The satellites were immature (see illustration). There is no constriction at the septum of the primite and little at that of the satellites. The epicyte and sarcocyte, collectively, are extremely thin, without the characteristic thickening at the anterior end described by Watson. (It should be noted that the

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**Of the author as well as of other investigators.
Unstarred information is of the author only.

only specimen of this species recognized was an association of three sporonts; one atypically elongate primite and two small satellites—a condition rarely observed in *Gregarina*.) The endoplasm of the primite is very opaque, and is yellow in reflected light; that of the satellites is translucent and practically colorless in reflected light. The nucleus of the primite was invisible, those of the satellites spherical, possessing many karyosomes.

The measurements are as follows: Length and width of primite protomerite, 75 by 80μ; of primite deutomerite, 425 by 100μ; of satellite protomerite 25 by 35 to 40μ; of satellite deutomerite, 125 to 140μ by 35 to 40μ, averaging 132.5 by 37.5μ. Total length of primite, 500μ; of satellite, 150 to 165μ, averaging 137.5μ. Total length of association, 637.5μ. Diameter of satellite nuclei, 15 to 18μ, averaging 16.5μ.

The proportions are as follows: Length of primite protomerite to total length, 1 : 6.7; of satellite, 1 : 6.0 to 1 : 6.6, averaging 1 : 6.3. Width of primite protomerite to width of deutomerite, 1 : 1.25; of satellite, 1 : 1.0.

No movement was observed.

No other stages in the life history were recognized.

Gregarina locustae Lankester, 1863. (Plate I, Fig. 18.)

References: Leidy, 1853a, 239; Leidy, 1856, 47; Diesing, 1859, 730; Lankester, 1863, 94; Léger, 1897, 10; Labbé, 1899, 35; Crawley, 1903a, 54; Crawley, 1903b, 640; Crawley, 1907, 225; Ellis, 1913c, 268; Watson, 1916a, 100.

Synonymy: *Gregarina Locustae Carolinae* Leidy, 1853a, 239; *G. Locustae Carolinae* Leidy, 1856, 47; *G. fimbriata* Diesing, 1859, 730; *G. Locustae* Lankester, 1863, 94; *G. locustaecarolinae* Labbé, 1899, 35; *Stephanophora locustaecarolinae*† Crawley, 1903a, 54; *G. locustaecarolinae* Crawley, 1907, 225; *G. locustae* Watson, 1916a, 100.

Hosts: ***Dissosteira carolina* (Linnaeus).

Habitat: *Alimentary canal; mid-intestine.

Distribution: Gary, Indiana; *Wyncote, Pennsylvania.

Description: The primite protomerite of the organism is greatly flattened and narrow; the deutomerite is cylindric. The satellite protomerite is similar to that of the primite, but is not flattened to the same extent; the deutomerite is cylindric. There is a marked constriction at the septum of both primite and satellite. The epicyte and sarcocyte of the association are extremely thin. The endoplasm is translucent, and is white in reflected light. The nuclei are spherical, with one karyosome each.

The measurements are as follows: Length and width of primite protomerite, 45 by 111μ; of primite deutomerite, 280 by 176μ; of satellite protomerite, 59 by 97μ; of satellite deutomerite, 280 by 163μ. Total length of primite, 325μ; of satellite, 339μ. Total length of association, 664μ. Diameter of nuclei (primite and satellite), 46μ.

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*Of other investigators only.

**Of the author as well as of other investigators.

Unstarred information is of the author only.

†One word.

The proportions are as follows: Length of primite protomerite to total length, 1 : 7.2; of satellite, 1 : 5.7. Width of primite protomerite to width of deutomerite, 1 : 1.6; of satellite, 1 : 1.7.

No movement was observed.

No other stages in the life history were recognized.

Gregarina kingi Crawley, 1907. (Plate I, Fig. 19.)

References: Crawley, 1907, 221; Sokolow, 1911, 279; Ellis, 1913c, 271; Watson, 1916a, 106.

Synonymy: *Gregarina kingi* Crawley, 1907, 221; *Gigaductus kingi* Ellis, 1913c, 271.

Hosts: ***Gryllus assimilis* Fabricius.

Habitat: *Alimentary canal; gizzard; enteric ceca; mid-intestine.

Distribution: *Beach Haven, New Jersey; Franklin and Washington Counties, Ohio; *Wyncote, Pennsylvania.

Description: The primite protomerite of the organism is dilated anteriorly and constricted at or below the middle; the deutomerite is a modified cylinder. The satellite protomerite is elongate and the deutomerite, cylindric to tapering posteriorly. There is a marked constriction at the septa. The epicyte and sarcocyte, collectively, are extremely thin throughout. The endoplasm is translucent, and is white in reflected light. The nuclei are spherical and contain one large karyosome each.

The measurements are as follows: Length and width of primite protomerite, 48 to 52μ by 32 to 34μ, averaging 50 by 33μ; of primite deutomerite, 91 to 100μ by 32 to 34μ, averaging 95.5 by 33μ; of satellite protomerite, 20 to 25μ by 35 to 38μ, averaging 22.5 by 36.5μ; of satellite deutomerite, 59 to 65μ by 35 to 38μ, averaging 62 by 36.5μ. Total length of primite, 139 to 152μ, averaging 145.5μ; of satellite, 79 to 90μ, averaging 84.5μ. Total length of association, 218 to 242μ, averaging 230μ. Diameter of nuclei (primite and satellite) 13 to 15μ, averaging 14μ.

The proportions are as follows: Length of primite protomerite to total length varies from 1 : 2.8 to 1 : 3.1, averaging 1 : 2.95; of satellite, 1 : 3.6 to 1 : 3.9, averaging 1 : 3.75. Width of primite protomerite to width of deutomerite, 1 : 1.0; of satellite, 1 : 1.0.

Movement was not observed. All of the organisms were attached to debris, usually posteriorly.

No other stages in the life history were recognized.

Gregarina galliveri Watson, 1915. (Plate I, Fig. 20.)

References: Watson, 1915, 33; Watson, 1916a, 111; Kamm, 1922a, 130; Kamm, 1922b, 84.

Synonymy: Name unchanged.

Hosts: ***Gryllus assimilis* Fabricius; *Hapithus agitator agitator* Uhler.

Habitat: *Alimentary canal; crop and gizzard; enteric ceca; mid-intestine.

Distribution: *Oyster Bay, New York; Franklin and Washington Counties, Ohio.

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*Of other investigators only.

**Of the author as well as of other investigators.

Unstarred information is of the author only.

Description: The primite protomerite of the adult is flattened and as wide as the deutomerite or wider; the deutomerite is cylindric, with undulation, to tapering posteriorly. The satellite protomerite is flattened and the deutomerite is cylindric to ellipsoid. There is little or no constriction at the septa. The epicyte and sarcocyte, collectively, are extremely thin throughout. The endoplasm of the association is moderately to considerably opaque and is shades of yellow in reflected light. The nuclei are spherical and contain no karyosomes.

The measurements are as follows: Length and width of primite protomerite, 30 to 52μ by 52 to 130μ, averaging 37.5 by 88μ; of primite deutomerite, 65 to 195μ by 45 to 104μ, averaging 144 by 74μ; of satellite protomerite, 26 to 45μ by 45 to 97μ, averaging 33 by 72.5μ; of satellite deutomerite, 85 to 247μ by 52 to 130μ, averaging 165 by 92μ. Total length of primite, 95 to 247μ, averaging 181.5μ; of satellite, 111 to 292μ, averaging 198μ. Total length of association, 206 to 539μ, averaging 379.5μ. Diameter of primite nucleus, 15 to 32μ, averaging 22μ; of satellite nucleus, 15 to 30μ, averaging 20μ.

The proportions are as follows: Length of primite protomerite to total length varies from 1 : 3.1 to 1 : 7.1, averaging 1 : 5.0; of satellite, 1 : 3.7 to 1 : 8.8, averaging 1 : 6.0. Width of primite protomerite to width of deutomerite varies from 1 : 0.65 to 1 : 1.0, averaging 1 : 1.0; of satellite, 1 : 1.0 to 1 : 1.5, averaging 1 : 1.2.

No movement was observed. All of the organisms were attached posteriorly to debris.

No other stages in the life history were recognized.

Comment: M. E. Watson (1916a, 111) states that the primite protomerite is always wider than the primite deutomerite. In approximately 25% of those examined in this study (from the same species of host) the widths of the two parts were the same.

Gregarina hadenoeci n. sp. (Plate I, Fig. 21; Plate II, Fig. 22.)

Hosts: *Hadenoecus puteanus* Scudder.

Habitat: Mid-intestine.

Distribution: Washington County, Ohio.

Description: The primite protomerite of the organism is a depressed sphere; the deutomerite is slightly tapering posteriorly. The satellite protomerite is a depressed sphere; the deutomerite is modified top-like. There is a very deep constriction at the septum of both primite and satellite. The epicyte and sarcocyte, collectively, are extremely thin. The endoplasm of the association is translucent, and is almost colorless in reflected light. The nuclei are spherical and have no karyosomes.

The measurements are as follows: Length and width of primite protomerite, 52 to 65μ by 71 to 100μ, averaging 58.5 by 85.5μ; of primite deutomerite, 162 to 227μ by 85 to 123μ, averaging 194.5 by 104μ; of satellite protomerite, 39μ by 65 to 91μ (average of latter, 78μ); of satellite deutomerite, 111 to 260μ by 85 to 150μ, averaging 185 by 117.5μ. Total length of primite, 214 to 292μ, averaging 253μ; of satellite, 150 to 299μ, averaging 225μ. Total length of association, 364 to 591μ, averaging 477μ. Diameter of primite nucleus, 25 to 26μ, averaging 25.5μ; of satellite nucleus (one visilbe), 26μ.

The proportions are as follows: Length of primite protomerite to total length varies from 1 : 4.1 to 1 : 4.5, averaging 1 : 4.3; of satellite, 1 : 4.8 to 1 : 7.7, averaging 1 : 6.25. Width of primite protomerite to width of deutomerite, 1 : 1.2; of satellite, 1 : 1.3 to 1 : 1.6, averaging 1 : 1.45.

No movement was observed.

Fourteen smaller sporonts were observed which were more top-like than the satellites (see illustration). No other stages were recognized.

Affinities: This organism resembles *Gregarina stygia* Watson, 1915, differing from it as follows: Sporonts of *Gregarina hadenoeci* n. sp. are tapering and top-like; those of *G. stygia* are barrel-shaped. The primite protomerite of *G. hadenoeci* is a depressed sphere; that of *G. stygia* is hemispherical. There is a deep constriction of the primite in *G. hadenoeci*, little in *G. stygia*. In *G. hadenoeci* the satellite deutomerite is wider than the primite deutomerite; in *G. stygia* it is usually narrower. Other minor differences may be noted.

Gregarina proteocephala n. sp. (Plate II, Figs. 23, 24, 25.)

Hosts: *Ceuthophilus gracilipes* (Haldeman).

Habitat: Mid-intestine.

Distribution: Washington County, Ohio.

Description: The primite protomerite of the organism is protean, exhibiting a deep, anterior, cup-like depression; the deutomerite is barrel-shaped to slightly tapering posteriorly. The satellite protomerite is continuous with the deutomerite, the two combined compartments forming an ellipse. The degree of constriction at the primite septum varies with the protean activity of the protomerite; there is little or no constriction at the satellite septum. The epicyte and sarcocyte, collectively, are of even thickness throughout, varying from 6.5μ down to an extremely thin layer. The endoplasm of the association is moderately to considerably opaque and is white in reflected light. The nuclei are spherical and possess no karyosomes.

The measurements are as follows: Length and width of primite protomerite vary greatly as a result of the protean activity. (See illustration.) Length and width of primite deutomerite, 111 to 195μ by 91 to 150μ, averaging 137 by 108μ; of satellite protomerite, 39 to 97μ by 85 to 150μ, averaging 165 by 113μ. Total length of primite, approximately 150 to 312μ, averaging 205μ; of satellite, 169 to 357μ, averaging 227μ. Total length of association, approximately 319 to 669μ, averaging 432μ. Diameter of nuclei, 32 to 39μ, averaging 33μ.

The proportions are as follows: Length of satellite protomerite to total length varies from 1 : 3.2 to 1 : 4.5, averaging 1 : 3.7. Width of satellite protomerite to width of deutomerite varies from 1 : 1.0 to 1 : 1.2, averaging 1 : 1.05.

The movement is slow with much torsion and flexion; that of the primite protomerite is almost ameboid.

Seven immature sporonts, six retaining epimerites, were observed. They were not found in the same specimens (but were in the same species of host), but did not resemble sporonts of the only other gregarinid (*Gregarina ceuthophili* n. sp.) recognized by the author from the same

species of host. The epimerite was a short, blunt cylinder (see illustration). (M. E. Watson, 1916a, 115, states that the epimerite of *Gregarina stygia* Watson, which probably came from the same host, is knobbed and slightly stalked.) The entire cephalont, or immature sporont, was very translucent.

Affinities: This organism resembles the gregarinid parasites of the ceuthophili, particularly *Gregarina longiducta* Ellis, but may be definitely set apart from all of them by the protean activity of the primite protomerite.

Comment: It is interesting to note that this gregarinid was taken from four of twelve specimens of *Ceuthophilus gracilipes* (Haldeman) from Washington County, Ohio, but from none of the forty-four specimens of the same species of insect taken in Fairfield County, Ohio.

Gregarina species. (Plate II, Fig. 26.)

Hosts: *Ceuthophilus divergens* Scudder.

Habitat: Mid-intestine.

Distribution: Franklin County, Ohio.

Description: The primite protomerite of the organism is an elongate hemisphere, and the deutomerite is ovoid. The satellite protomerite is hemispherical and the deutomerite ovoid. There is little constriction at the septa. The epicyte and sarcocyte were not recognized, hence they are probably very thin. The endoplasm of the association is opaque, and is white in reflected light. The nuclei were not visible.

The measurements are as follows: Length and width of primite protomerite, 45 by 52μ; of primite deutomerite, 156 by 65μ; of satellite protomerite, 36 by 43μ; of satellite deutomerite, 90 by 59μ. Total length of primite, 191μ; of satellite, 126μ. Total length of association, 317μ.

The proportions are as follows: Length of primite protomerite to total length, 1 : 4.2; of satellite, 1 : 3.5. Width of primite protomerite to width of deutomerite, 1 : 1.3; of satellite, 1 : 1.4.

No movement was observed.

No other stages were recognized.

Affinities: This organism resembles *Gregarina consobrina* Ellis, differing from it in the length to width ratio of the deutomerites. In *Gregarina* sp. length of deutomerites is over twice the width; in *G. consobrina* length and width are approximately equal.

Comment: Insufficient characterization makes it inadvisable to name the apparently new species at this time.

Gregarina ceuthophili n. sp. (Plate II, Figs. 27 to 30.)

Hosts: *Ceuthophilus gracilipes* (Haldeman); *C. brevipes* Scudder; *C. divergens* Scudder.

Habitat: Mid-intestine.

Distribution: Fairfield, Franklin, Licking, and Washington Counties, Ohio.

Description: The primite protomerite of the organism is polymorphic, varying from an irregular hemisphere to a cone with a blunt apex; the deutomerite is ellipsoid to tapering anteriorly. The satellite

protomerite is almost hemispherical and is continuous with the deutomerite; the latter is ovoid and elongate, sometimes with marked posterior tapering. There is a marked constriction at the primite septum; none at the satellite septum. The epicyte and sarcocyte, collectively, are usually extremely thin, but may occasionally be as much as three microns in the primite protomerite. The endoplasm of the association is translucent to moderately opaque, and is white in reflected light. The nuclei are spherical, each containing one large karyosome.

The measurements are as follows: Length and width of primite protomerite, 28 to 59μ by 45 to 71μ, averaging 45 by 62μ; of primite deutomerite, 111 to 265μ by 60 to 117μ, averaging 200 by 92.5μ; of satellite protomerite, 20 to 39μ by 45 to 111μ, averaging 33 by 85.5μ; of satellite deutomerite, 95 to 337μ by 52 to 111μ, averaging 249 by 94μ. Total length of primite, 139 to 324μ, averaging 245μ; of satellite, 115 to 376μ, averaging 282μ. Total length of association, 254 to 700μ, averaging 527μ. Diameter of primite nucleus, 25 to 39μ, averaging 33μ; of satellite nucleus, 25 to 45μ, averaging 36μ.

The proportions are as follows: Length of primite protomerite to total length varies from 1 : 5.0 to 1 : 6.0, averaging 1 : 5.4; of satellite, 1 : 5.7 to 1 : 9.6, averaging 1 : 8.2. Width of primite protomerite to width of deutomerite, 1 : 1.25 to 1 : 1.7, averaging 1 : 5.0; of satellite, 1 : 1.0 to 1 : 1.3, averaging 1 : 1.1.

The movement is rapid and in a straight line.

Numerous immature sporonts were recognized. They are characterized by the shape of the protomerite (a depressed sphere) and an elongate and tapering deutomerite. Several intergradations between this condition and that of the associated sporonts were observed. Ten cysts (same species?) were observed. These were spherical and averaged 215μ in diameter, not including the transparent outer layer, which was 30μ in thickness. Three cysts, kept in a thin film of water in a moist chamber, were reduced approximately 80μ in diameter, and were attacked by a mold after three days of observation. Dehiscence failed to take place. No other stages were recognized.

Affinities: This organism resembles several of the gregarinid parasites of the ceuthophili, particularly *Gregarina neglecta* Watson, differing from it as follows: The primite protomerite of *G. ceuthophili* n. sp. is irregularly hemispherical to conic with a blunt apex; that of *G. neglecta* is cap-like, very short and continuous with the deutomerite, and papillate at the apex. *G. ceuthophili* may have a marked constriction at the septum; *G. neglecta* has little or no constriction. The satellite deutomerite is elongate in *G. ceuthophili;* obese in *G. neglecta.* Minor differences may be noted.

Gregarina prima n. sp. (Plate II, Fig. 31.)

Hosts: *Ceuthophilus uhleri* Scudder.

Habitat: Mid-intestine.

Distribution: Fairfield and Logan Counties, Ohio.

Description: The primite protomerite of the organism is a depressed hemisphere; the deutomerite is cylindric to ovoid. The satellite

protomerite is flattened and the deutomerite cylindric. A thick hyaline connective is present between the primite and satellite—a condition unique among the gregarinids described in this paper. There is a slight constriction at the septum of the primite, a deep one at that of the satellite. The epicyte and sarcocyte, collectively, are extremely thin. The endoplasm of the association is moderately opaque, and is white in reflected light. The nuclei are spherical and contain no karyosomes.

The measurements are as follows: Length and width of primite protomerite, 30 to 66μ by 48 to 52μ, averaging 49 by 51μ; of primite deutomerite, 77 to 127μ by 57 to 97μ, averaging 108 by 78μ; of satellite protomerite, 18 to 30μ by 52 to 60μ, averaging 23 by 55μ; of satellite deutomerite, 97μ by 75 to 77μ (average of latter, 76μ). Length of primite, 107 to 193μ, averaging 157μ; of satellite, 115 to 127μ, averaging 120μ. Total length of association, 222 to 320μ, averaging 277μ. Diameter of nuclei, 14 to 19μ, averaging 16μ.

The proportions are as follows: Length of primite protomerite to total length varies from 1 : 2.8 to 1 : 3.5, averaging 1 : 3.3; of satellite, 1 : 4.2 to 1 : 6.4, averaging 1 : 5.3. Width of primite protomerite to width of deutomerite varies from 1 : 1.5 to 1 : 1.9, averaging 1 : 1.7; of satellite, 1 : 1.25 to 1 : 1.5, averaging 1 : 1.4.

No movement was observed.

No additional stages were recognized.

Affinities: This organism resembles *Gregarina udeopsyllae* Watson, differing from it as follows: The primite protomerite of *G. prima* is a depressed hemisphere; that of *G. udeopsyllae* is papillate. *G. prima* has little constriction at the septum of the primite; *G. udeopsyllae* has a marked constriction. Minor differences may be noted.

Gregarina acrydiinarum n. sp. (Plate II, Figs. 32 to 35.)

Hosts: *Acrydium arenosum angustum* Hancock; *Paratettix cucullatus cucullatus* (Burmeister).

Habitat: Mid-intestine.

Distribution: Delaware and Franklin Counties, Ohio.

Description: The primite protomerite of the organism is somewhat protean, but is usually cylindric, terminating bluntly; the deutomerite is ovoid to cylindric. The satellite protomerite is flattened almost to the point of obliteration; the deutomerite is ellipsoid to cylindric. There is a marked constriction at each of the septa. The epicyte and sarcocyte, collectively, are extremely thin. The endoplasm of the association is translucent and is shades of yellow to orange in reflected light. The nuclei are spherical and contain no karyosomes.

The measurements are as follows: Length and width of primite protomerite, 26 to 45μ by 32 to 52μ, averaging 36 by 40μ; of primite deutomerite, 104 to 169μ by 65 to 136μ, averaging 137 by 96μ; of satellite protomerite (omitting length, which is negligible), 30 to 54μ (width), averaging 47μ; of satellite deutomerite, 143 to 208μ by 70 to 143μ, averaging 174 by 96μ. Length of primite, 130 to 214μ, averaging 173μ; of satellite, 143 to 208μ, averaging 174μ. Total length of association, 273 to 422μ, averaging 347μ. Diameter of nuclei, 23 to 32μ, averaging 29μ.

The proportions are as follows: Length of primite protomerite to total length varies from 1 : 4.3 to 1 : 6.1, averaging 1 : 4.9. Width of primite protomerite to width of deutomerite varies from 1 : 2.0 to 1 : 2.6, averaging 1 : 2.4; of satellite, 1 : 1.3 to 1 : 2.8, averaging 1 : 2.1.

The movement of the organism as a whole is a very slow gliding with some flexion. The primite protomerite is protean to the extent of bending and wrinkling like the flexible snout of some mammals. It always becomes cheese-box-like (Fig. 35) when fixed and stained.

Six cysts, spherical and of the same color as the sporonts, were observed, but were mashed under the cover-slip. This was the only time which this accident occurred with the cysts of gregarinids, which are usually very resistant. No other stages were recognized.

Affinities: This organism somewhat resembles *Gregarina ovata* Dufour, differing from it chiefly as follows: The primite protomerite of *G. acrydiinarum* is cylindric; that of *G. ovata* is a depressed sphere. The satellite protomerite of *G. acrydiinarum* is almost obliterated; that of *G. ovata* is somewhat flattened. The satellite deutomerite of *G. acrydiinarum* is ellipsoid to cylindric; that of *G. ovata* is ovoid.

Gregarina oviceps Diesing, 1859. (Plate II, Fig. 36.)

References: Leidy, 1853a, 238; Leidy, 1856, 47; Diesing, 1859, 728; Lankester, 1863, 94; Labbé, 1899, 35; Crawley, 1903a, 45; Crawley, 1903b, 639; Crawley, 1907, 220; Ellis, 1913c, 266; Watson, 1915, 34; Watson, 1916a, 101; Bhatia and Setna, 1924, 287.

Synonymy: *Gregarina Achetae abbreviatae* Leidy, 1853a, 238; *G. oviceps* Diesing, 1859, 728; *G. Achetae* Lankester, 1863, 94; *G. achetaeabbreviatae* Labbé, 1899, 35; *G. achetae-abbreviatae* Crawley, 1907, 220.

Hosts: ***Gryllus assimilis* Fabricius; **Gryllus* spp.

Habitat: *Alimentary canal; **gizzard; **mid-intestine.

Distribution: *Lahore, India; *Urbana, Illinois; *Douglas Lake, Michigan; *Beach Haven, New Jersey; *Oyster Bay, New York; Franklin and Washington Counties, Ohio; *Haverford, Philadelphia, and Wyncote, Pennsylvania.

Description: The primite protomerite of the organism is flattened and wide; the deutomerite is ovoid and obese. The satellite protomerite is a modified hemisphere; the deutomerite ovoid and obese. There is a marked constriction at the septum of the primite, little at that of the satellite. The epicyte and sarcocyte, collectively, of the association are extremely thin. The endoplasm of the association is very opaque and is white to yellowish in reflected light. The nuclei were not visible.

The measurements are as follows: Length and width of primite protomerite, 65 to 71μ by 150 to 180μ, averaging 68 by 165μ; of primite deutomerite, 150 to 195μ by 160 to 180μ, averaging 177.5 by 170μ; of satellite protomerite, 70 to 71μ by 105 to 117μ, averaging 70.5 by 111μ; of satellite deutomerite, 175 to 228μ by 160 to 193μ, averaging 201.5 by 172.5μ. Length of primite, 215 to 266μ, averaging 245.5μ; of satellite,

*Of other investigators only.
**Of the author as well as of other investigators.
Unstarred information is of the author only.

245 to 299μ, averaging 272μ. Total length of association, 460 to 565μ, averaging 517.5μ.

The proportions are as follows: Length of primite protomerite to total length varies from 1 : 3.3 to 1 : 3.7, averaging 1 : 3.5; of satellite protomerite, 1 : 3.5 to 1 : 3.7, averaging 1 : 3.6. Width of primite protomerite to width of deutomerite varies from 1 : 1.0 to 1 : 1.01; of satellite, 1 : 1.5 to 1 : 1.6, averaging 1 : 1.55.

No movement was observed.

No other stages were recognized.

Pileocephalus tachycines n. sp. (Plate II, Figs. 37 to 39.)

Hosts: *Tachycines asinamorus* (Adelung).

Habitat: Mid-intestine.

Distribution: Franklin County, Ohio.

Description: The protomerite is usually a depressed hemisphere; the deutomerite is usually irregularly ovoid to cylindric. There is a marked to slight constriction at the septum. The epicyte and sarcocyte, collectively, are extremely thin. The endoplasm is very opaque and is white in reflected light. The nucleus is spherical and contains one very large karyosome.

The measurements are as follows: Length and width of protomerite, 16 to 39μ by 35 to 65μ, averaging 24 by 44μ; of deutomerite, 91 to 121μ by 55 to 85μ, averaging 106 by 64μ. Total length of the organism, 107 to 160μ, averaging 130μ. Diameter of nucleus, 20 to 32μ, averaging 26μ.

The proportions are as follows: Length of protomerite to total length varies from 1 : 3.8 to 1 : 6.8, averaging 1 : 5.5; width of protomerite to width of deutomerite varies from 1 : 1.3 to 1 : 1.6, averaging 1 : 1.5.

There is usually no movement; when it occurs it is very slow.

Three cephalonts were recognized. The epimerite is a modified cone, the protomerite a modified depressed hemisphere with apical depression and lateral constriction. One cyst was observed. This was spherical, 130μ in diameter (transparent envelope not present), very opaque, and white in reflected light. No additional stages were recognized.

Affinities: This organism resembles *Pileocephalus blaberae* (Frenzel), differing chiefly as follows: The epimerite of *P. tachycines* is a modified cone; that of *P. blaberae* is lance-like and swollen at the base. The sporont of *P. tachycines* is not over 160 microns in length; the average length of *P. blaberae* is 500 microns.

Actinocephalus species. (Plate II, Fig. 40.)

Hosts: *Pardalophora apiculata* (Harris).

Habitat: Mid-intestine.

Distribution: Washington County, Ohio.

Description: The "protomerite" is flattened and truncated; the "deutomerite" is a compressed sphere. (The tail-like posterior extension—see illustration—might have been a temporary cellular compression, as would be suggested by the presence of numerous parallel myoneme-like structures lying closely contiguous.) There is no con-

striction in the region of a possible septum. (Apparently this organism—one specimen observed—possesses no septum. The opacity would make it difficult to see the septum in vivo, but it failed to appear after the organism had been stained and permanently mounted.) The epicyte and sarcocyte, collectively, are about 3μ in thickness throughout. The endoplasm is very opaque, and is white in reflected light. The nucleus is a flattened sphere, containing 4 large karyosomes.

The measurements are as follows: Length and width of "protomerite," 110 by 195μ; of "deutomerite," 680 by 290μ. Total length of organism, 790μ. Size of nucleus, 78 by 97μ.

The proportions are as follows: Length of "protomerite" to total length, 1 : 7.2; width of "protomerite" to width of "deutomerite," 1 : 1.5.

The movement is a very slow gliding in a straight line.

No other stages were recognized.

Affinities: All known characters, except the apparent lack of a septum, would indicate a close relationship between this organism and the other actinocephali of Orthoptera.

Actinocephalus elongatus n. sp. (Plate II, Figs. 41 to 43.)

Hosts: *Dichromorpha viridis* (Scudder); *Arphia sulphurea* (Fabricius); *Chortophaga viridifasciata* (DeGeer); *Schistocerca americana americana* (Drury) (*A. elongatus* n. sp., ?); *Melanoplus mexicanus mexicanus* (Saussure) (*A. elongatus* n. sp. ?).

Habitat: Celom; enteric ceca; mid-intestine.

Distribution: Fairfield, Franklin, and Washington Counties, Ohio.

Description: The protomerite is usually a depressed hemisphere; the deutomerite is elongate, tapering irregularly to a blunt point. There is little or no constriction at the septum. The epicyte and sarcocyte, collectively, are from 6 to 26μ in thickness in the protomerite and about 6μ (average) in the deutomerite. The endoplasm is very opaque (usually black) and is white in reflected light. The nucleus is spherical and contains no karyosomes.

The measurements are as follows: Length and width of protomerite, 65 to 130μ by 130 to 202μ, averaging 100 by 163μ; of deutomerite, 306 to 682μ by 111 to 200μ, averaging 482 by 165μ. Total length of organism, 371 to 812μ, averaging 582μ. Diameter of nucleus, 45 to 62μ, averaging 54.5μ.

The proportions are as follows: Length of protomerite to total length varies from 1 : 5.0 to 1 : 7.5, averaging 1 : 5.8; width of protomerite to width of deutomerite varies from 1 : 0.9 to 1 : 1.2, averaging 1 : 1.0.

No movement was observed. The organism is usually attached posteriorly to debris.

One cephalont was observed. This possessed a broad epimerite with a number of short, finger-like processes (10 perceptible). No other stages were recognized.

Affinities: This organism resembles *Actinocephalus fimbriatus* (Diesing), differing as follows: The protomerite of *A. elongatus* is a depressed hemisphere; that of *A. fimbriatus* is an almost perfect sphere.

The deutomerite of *A. elongatus* is elongate, tapering irregularly to a blunt point; that of *A. fimbriatus* is ovoid, tapering slightly.

Infusoria

Nyctotherus ovalis Leidy, 1850, variety? (Plate II, Fig. 44.)

References: Siebold, 1839, 69; Leidy, 1850, 100; Leidy, 1853b, 244; Leidy, 1853c, 41; Stein, 1854, 42; Leidy, 1856, 43; Stein, 1856, 36; Claparède and Lachmann, 1858, 240; Stein, 1859, 78, 84, 85, 90; Stein, 1860, 50; Stein, 1862; Stein, 1867, 344; Leidy, 1879, 204; Grassi, 1881, 197; Schuster, 1898, 244; Belar, 1916, 242; Zulueta, 1916, 5; Kudo, 1922, 113; Yakimoff and Miller, 1922a, 9; Yakimoff and Miller, 1922b, 133; Pinto, 1926, 14; Tejera, 1926, 1382; Bhatia and Gulati, 1927, 86, 113, 116; Lucas, 1927, 224, 232; Lucas, 1928, 161; Weill, 1929, 22; McAdow, 1931, 16; Balch, 1932, 237.

Synonymy: "Leucophrys-artiges Infusorium" Siebold, 1839, 69; *Nyctotherus ovalis* Leidy, 1850, 100; *Bursaria blattarum* Stein, 1854, 42; *Plagiotoma Blattarum* Claparède and Lachmann, 1858, 240; *Plagiotoma blattarum* Stein, 1859, 78 et al.

Hosts: **Blattella germanica* (Linnaeus); *Parcoblatta pensylvanica* (DeGeer); **Blatta orientalis* Linnaeus; **Periplaneta americana* (Linnaeus); **Gryllotalpa gryllotalpa* Linnaeus; *undetermined species of woods-cockroaches.

Habitat: *Alimentary canal; *mid-intestine; **hind-intestine; *colon; *rectum.

Distribution: *Brazil; *London, England; *French Indo-China; *Berlin, Germany; *Lahore, India; *Urbana, Illinois; *Ohio; Champaign County, Ohio.

Description: The organism is ovoid in shape with cilia uniformly distributed over the body. Its measurements are 78 to 104μ by 104 to 136μ. The peristome starts just back of the anterior end, bending laterally to the right and paralleling the anterior end, and then extends posteriorly a little over half way down the organism. The peristome of the typical *N. ovalis* Leidy is at right angles to that of this organism, starting just back of the anterior end, extending posteriorly, then bending laterally to the left.

A cytostome was not visible.

A cytopyge is present at the extreme posterior end, extending somewhat laterally. It averages about 20μ in length.

One large vacuole (19μ, maximum diameter) is present, usually in the region of the cytopyge, sometimes farther anterior. Two or three smaller vacuoles, varying greatly in size, are scattered throughout the posterior half of the organism. These were not seen in vivo, hence it is not known which were contractile.

The macronucleus is usually elongate (about 19 by 45μ), somewhat dumb-bell shaped, with its longitudinal axis at right angles to that of

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*Of other investigators only.
**Of the author as well as of other investigators.
Unstarred information is of the author only.

the organism. The macronucleus of the typical *N. ovalis* approximates a fusiform appearance.

The micronucleus was not visible.

Affinities: This organism may be a variety of *N. ovalis*, or possibly a distinct species. However, only a limited amount of material for identification was available, as it was found in only one host (of 70 specimens of Blattidae).

SUMMARY

Fourteen newly described species and one new subspecies of protozoan parasites were recognized in this study, in addition to nine species which had been previously described by other investigators. Twenty-two (or twenty-four?) new hosts were named and new parasites were added for twelve (or ten?) orthopteran hosts which had been previously studied by others. (The exact number is uncertain because of certain incorrect host determinations made by other investigators.)

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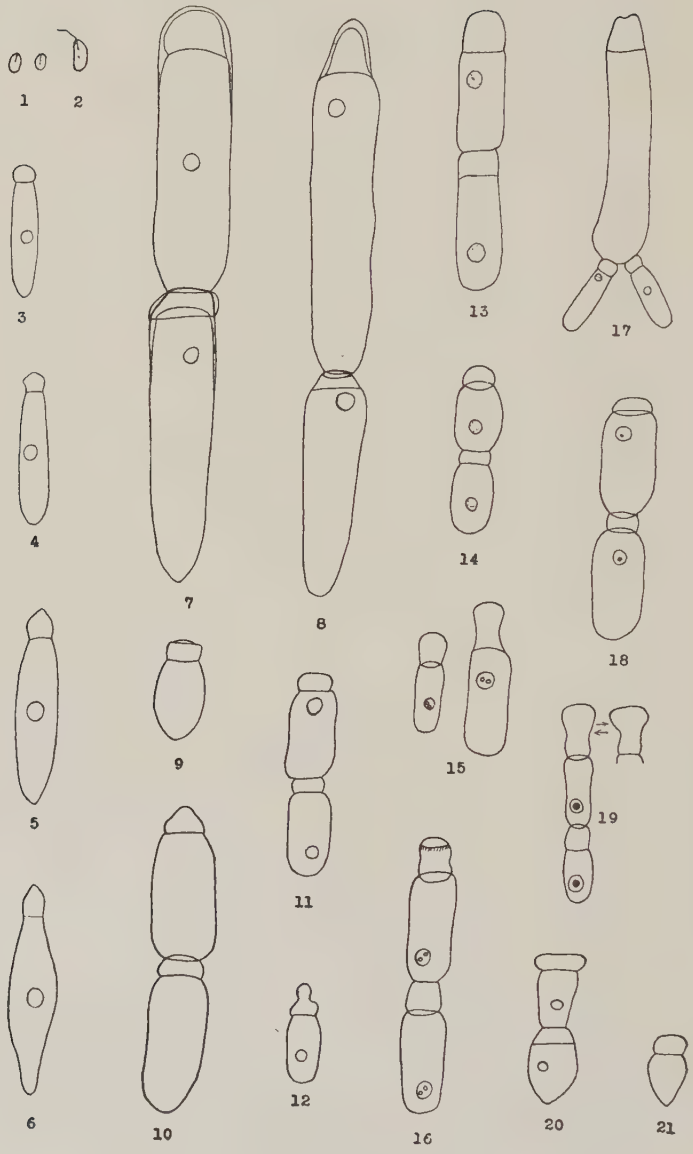
EXPLANATION OF PLATES

Plate I

Fig. 1. *Leptomonas* sp., *Leishmania* stage?
Fig. 2. *Leptomonas* sp., *Leptomonas* stage.
Fig. 3. *Leidyana gryllorum* (Cuénot), adult sporont.
Figs. 4, 5, 6. *Leidyana erratica* (Crawley), adult sporonts.
Fig. 7. *Gregarina ohioensis* n. sp., adult association.
Fig. 8. *Gregarina thomasi* n. sp., adult association.
Fig. 9. *Gregarina parcoblattae* n. sp., immature sporont.
Figs. 10, 11. *Gregarina parcoblattae* n. sp., adult associations.
Fig. 12. *Gregarina rigida columna* n. subsp. or *G. r. rigida* (Hall) (?), cephalont.
Fig. 13. *Gregarina rigida columna* n. subsp., adult association.
Fig. 14. *Gregarina r. rigida* (Hall), adult association.
Fig. 15. *Gregarina indianensis* n. sp., immature sporonts.
Fig. 16. *Gregarina indianensis* n. sp., adult association.
Fig. 17. *Gregarina nigra* Watson (atypical as to width-length proportions), association of one adult and two immature sporonts.
Fig. 18. *Gregarina locustae* Lankester, adult association.
Fig. 19. *Gregarina kingi* Crawley, small adult association.
Fig. 20. *Gregarina galliveri* Watson, adult association.
Fig. 21. *Gregarina hadenoeci* n. sp., immature sporont.

Plate II

Fig. 22. *Gregarina hadenoeci* n. sp., adult association.
Fig. 23. *Gregarina proteocephala* n. sp., adult association.
Fig. 24. *Gregarina proteocephala* n. sp., cephalont (of this species?).
Fig. 25. *Gregarina proteocephala* n. sp., primite of adult association, showing another occasional shape.
Fig. 26. *Gregarina* sp., adult association.
Fig. 27. *Gregarina ceuthophili* n. sp., immature sporont.
Figs. 28, 29. *Gregarina ceuthophili* n. sp., adult associations.
Fig. 30. *Gregarina ceuthophili* n. sp., cyst (of this species?), illustrating amount of shrinkage in three days. Arrows indicate shrinkage.
Fig. 31. *Gregarina prima* n. sp., adult association.
Figs. 32, 33. *Gregarina acrydiinarum* n. sp., adult associations.
Fig. 34. *Gregarina acrydiinarum* n. sp., primite protomerites, illustrating characteristic change of shape.
Fig. 35. *Gregarina acrydiinarum* n. sp., primite protomerite after fixing and staining.
Fig. 36. *Gregarina oviceps* Diesing, small association (probably immature).
Fig. 37. *Pileocephalus tachycines* n. sp., cephalont.
Fig. 38. *Pileocephalus tachycines* n. sp., epimerite of another shape.
Fig. 39. *Pileocephalus tachycines* n. sp., sporonts (of adult age approximately).
Fig. 40. *Actinocephalus* sp., adult sporont.
Fig. 41. *Actinocephalus elongatus* n. sp., cephalont.
Figs. 42, 43. *Actinocephalus elongatus* n. sp., adult sporonts (adhering to debris in Fig. 43).
Fig. 44. *Nyctotherus ovalis* Leidy (probably a variety).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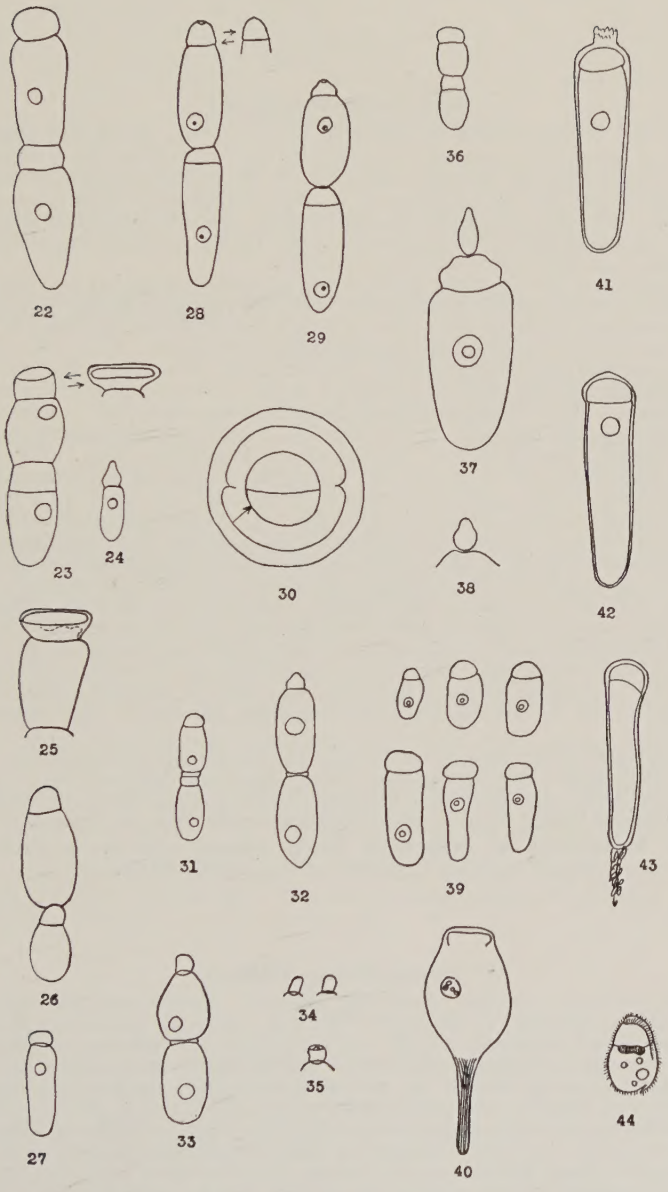
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BOOK NOTICES

Sedimentary Petrography

This is a revised edition of Professor Tickell's book, which first appeared in 1931. It is essentially a manual of laboratory practice in the field of sedimentary petrography, presenting methods selected from the techniques developed not only by geologists, but also by investigators in other fields such as hydrology, chemical engineering, ceramics, and petroleum engineering. Successive chapters are devoted to size analysis, porosity and permeability, preparation of specimens, identification of minerals, and description of detrital minerals.

The only notable difference between this and the first edition is in the chapter on porosity and permeability, which has been rewritten in enlarged and improved form. Elsewhere there are only minor changes and additions, and for the chapter on size analysis the revision has been decidedly inadequate. Since 1931 extensive progress has been made in many fields of investigation concerned with the problems of size analysis, and the author's cognizance of this new material has been casual, to say the least. This chapter might well have been rewritten just as thoroughly as the one on porosity, not only for the addition of new and important material, but also to correct a certain lack of balance among important topics. For example, space is taken for types of curves that are rarely, if ever useful to the student of sediments, and a larger number of curves is represented than actually necessary in a work of this size, whereas no directions are given for the preparation of the frequency distribution curve, a bothersome question for the neophyte in sedimentary analysis. Another element missing in this chapter is treatment of the problem, highly important to the geologist, of disaggregating sedimentary rocks for size analysis.

The chapters on mineral identification contain much valuable material and should serve well as a guide to anyone who has had at least an introduction to the microscopic techniques involved, but that they would provide means of salvation for "one who has the ordinary scientific fundamentals" (to quote the author) without any special training in optical mineralogy may well be doubted. As basis for a laboratory course in the subject, with competent instruction, they should serve admirably.

Probably no single book could contain all that the laboratory student of sediments might desire, nor present the subject from all desirable points of view. Among the works now available, Professor Tickell's book should be on the shelf of every serious worker in sedimentary petrology.—*Edmund M. Spieker.*

The Examination of Fragmental Rocks, revised edition, by Frederick G. Tickell. x+154 pp. Stanford University Press, 1939. $4.00.

Another Biology Testbook

This book has a number of excellent features. Nearly every phase of biology (except animal behavior) is discussed. There is a brief but complete survey of the animal and plant kingdoms, and the various systems and processes in living organisms are discussed on a comparative basis. Human biology is stressed in the chapters on animals. Separate chapters are devoted to the ecology and economic importance of plants and animals, to applied biology, and to biochemical and biophysical processes—subjects often omitted from elementary texts. There is a very complete glossary, and an index of Latin and Greek word roots, features which will be appreciated by both student and instructor. At the end of each chapter is a list of review questions. The book is well bound, and is printed on the new "eye-toned" paper.

Even with its desirable features this book is disappointing. The author has attempted to cover too much ground, and as a result the treatment of most subjects is very sketchy. The discussion is teleological. The book contains many state-

ments that are either inaccurate or misleading; for example, in Chapter 8, in characterizing the triploblastic phyla of animals is the statement, "The body wall is triploblastic, being made of three cellular layers, ectoderm, mesoderm, and entoderm;" in characterizing the phylum Chordata, p. 159, is the statement, "Pharyngeal clefts (gill slits) are present for respiration purposes at some stage of the life history;" in illustrating predaciousness, p. 499, is the statement, "Chicken hawks are predacious on chickens." The illustrations in the book, except for a few that are borrowed, are very poor. In discussing the various organ systems in animals, the author does little more than list the structures composing these systems in 28 representative animals.

Except in the chapter on heredity (which is one of the best chapters in the book), the experimental approach to biological problems and principles is almost never used. Almost nothing in the way of experimental data, from which the student might draw his own conclusions, is given. Such an approach would seem particularly appropriate in the discussions of physiology, ecology, and evolution.

—*D. J. Borror.*

Fundamentals of Biology, by William C. Beaver. 896 pp. St. Louis, The C. V. Mosby Co., 1939. $4.50.

Essays in Philosophical Biology

Friends of the late William Morton Wheeler have gathered together some of his occasional papers and published them in book form. Reprints of some of the articles were exhausted and for many none existed. Consequently the publication of this volume fills the need of preserving these articles for posterity. All present day biologists are acquainted with his many contributions to science, but many may not have had the opportunity of reading some of the papers presented in this volume.

The contents by chapters are as follows: The Ant-Colony as an Organism; Jean-Henri Fabre; On Instincts; The Termitodoxa, or Biology and Society; The Organization of Research; The Dry-Rot of Our Academic Biology; Emergent Evolution and the Development of Societies; Carl Akeley's Early Work and Environment; Present Tendencies in Biological Theory; Hopes in the Biological Sciences; Some Attractions of the Field Study of Ants; Animal Societies. A foreword by Thomas Barbour and an obituary by his colleagues precedes the essays. An excellent photograph of Dr. Wheeler forms the frontispiece.

This volume should be read from cover to cover by every biologist, both young and old. It reflects the knowledge and philosophy of one who has achieved much in science. All the essays are excellent but it seems that the reviewer would be doing an injustice if he did not recommend especially the one entitled "The Dry-Rot of Our Academic Biology." This is cleverly written and reflects the inimitable style of Dr. Wheeler.—*R. H. Davidson.*

Essays in Philosophical Biology, by William Morton Wheeler, selected by Prof. G. H. Parker. xv+261 pp. Harvard University Press, Cambridge, Massachusetts, 1939. $3.00.

The Sun

This book is a translation of the book "Il Sole," by an Italian. It is a remarkable book in many ways, in its virtues and in its faults, both of which it possesses in good measure. Its chief virtues are that it is well written and profusely illustrated. It has, in fact, 157 illustrations in 350 pages. The style is straightforward and non-technical so that the reader with only a general scientific background can follow the presentation easily and profitably.

The faults of the book may be divided into two groups, those due to the publisher and those due to the author. Among the former are the following: The book is printed in glazed paper which catches the light and glares abominably into the reader's eyes. The index is inexcusably incomplete. Among the faults which may be laid to the author are, first, that too great an emphasis has been laid upon the Royal Observatory (Italian) at Arcetri. The reader distinctly gets the impression

that there are other observatories elsewhere but that the most important one is that of the author. Only passing mention is made of the work of the McMath-Hulbert Observatory of the University of Michigan which is generally conceded to represent the most outstanding development in solar observatories of recent times.

The same may be said of Mr. Abetti's discussion of diffraction gratings. Mt. Wilson Observatory furnished Mr. Abetti with a grating. This was in itself rather unusual, because Mt. Wilson Observatory does not make many gratings for other than its own use. The grateful author makes no reference either to R. W. Wood of Johns Hopkins or H. G. Gale of the University of Chicago, both of whom toil to supply the scientific world with gratings.

In short, Mr. Abetti creates the impression that he is a scholar and a master of his subject in spite of being insulated from the rest of the world. In the face of these rather harsh comments, the reviewer wishes to recommend the book, particularly to those who wish to read a well written, earnest account of what is known about our nearest star.—*C. E. Hesthal.*

The Sun, by Geiorgio Abetti, translation by Alexandre Zimmerman and Frans Borghouts. 360 pp. New York, D. Van Nostrand Co., 1938. $5.00.